

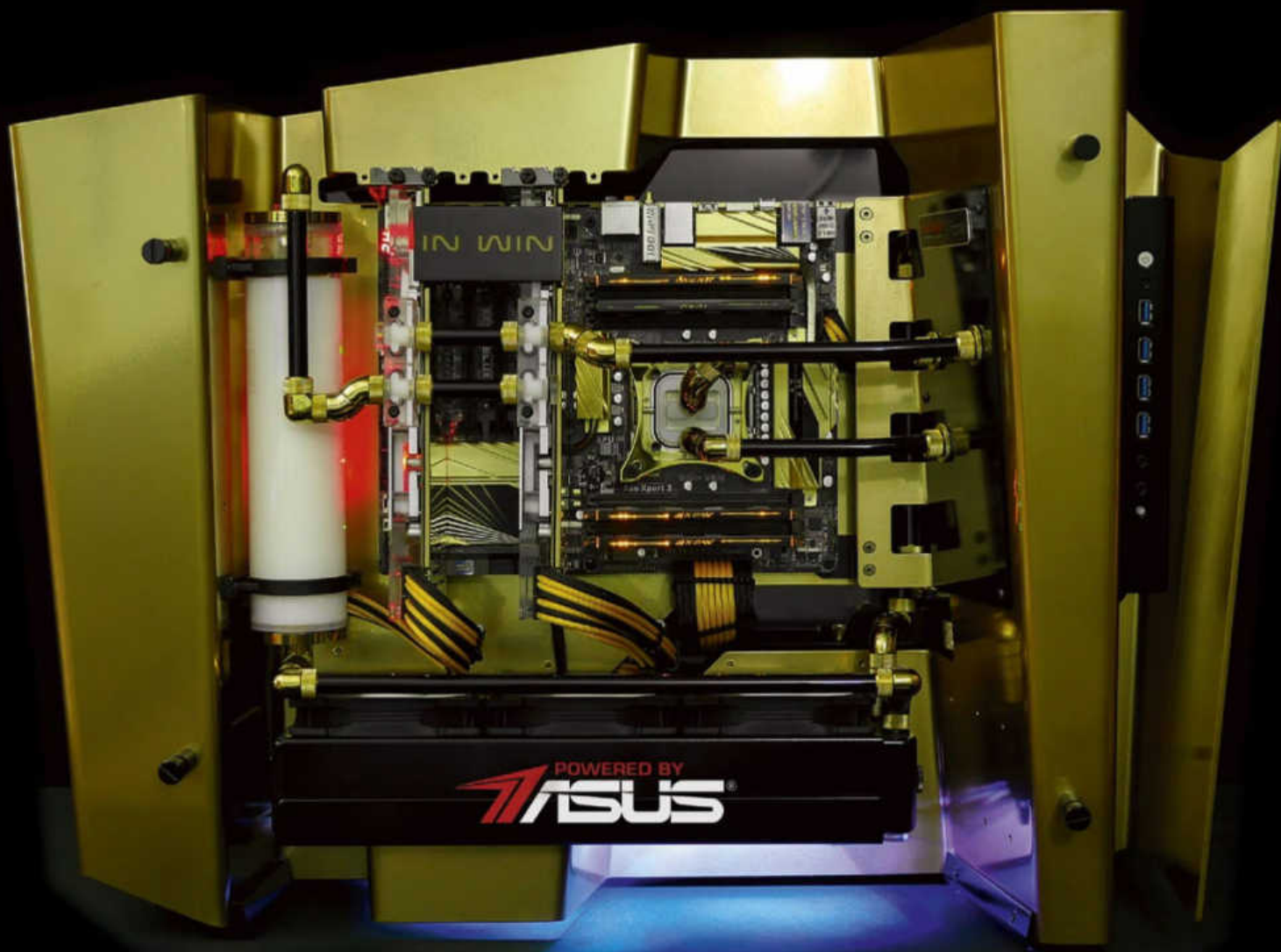
NETWORK GET THE BEST FROM YOUR BROADBAND CONNECTION

OVERCLOCKING HOW TO SQUEEZE OUT THAT EXTRA SPEED

AUSTRALIA'S **PC** GAMING MAG

PC PowerPlay

Technical Handbook



PERFORMANCE TWEAKING

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STEALING YOUR CYCLES?

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TAKES TO MAKE IT?

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ASUS believes in delivering the best solution for a given usage scenario. While many other companies are only just now starting to acknowledge the unique needs and wants of gamers and the PC gaming usage scenario, ASUS has been prepared and delivering for many years. Creating the ASUS Republic of Gamers, or ROG for short, almost 10 years ago, the Republic of Gamers range aspires to deliver to you a premium, gaming focused solution.

The Republic of Gamers (ROG) was initially launched on the motherboard product range, including such legendary motherboards as the ROG Commando on the Intel P965 chipset and the original ROG Rampage on the Intel X48 chipset. Since these early days, the ROG product range has continued to evolve, delivering ever more gaming focused solutions and now spanning across a variety of product categories.



With the Intel Z170 based ROG Maximus VIII Series pushing the boundaries of connectivity and platform flexibility, there is a selection of gaming focused solutions for gamers. Whether you're looking for a small but mighty mini-ITX solution, such as the Maximus VIII Impact, or a gaming board that delivers the best-in-class audio and overclocking features such as the Maximus VIII Extreme Assembly or looking for a well-rounded entry into the ROG family through the Maximus VIII Ranger, there is something for every gamer.

Maximus VIII Extreme


It's difficult to talk about PC games and PC gaming without acknowledging the importance of a good display through which to immerse yourself in the game world. Having claimed the title awarded by PC PowerPlay for the Best Gaming Monitor for 2014 (awarded February 2015), the PG278Q ROG SWIFT set firm foundations on which to further evolve and finesse. Breaking through with evermore impressive specs, like a massive 165Hz refresh rate from an In-Plane Switching (IPS) panel, the new PG279Q ROG SWIFT sets the bar even higher, producing an unmatched gaming experience that you'll wonder how you ever gamed without it! This isn't just ASUS preaching, it's the overwhelming feedback from gamers like you during PAX 2015.



PG279Q



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ROG Matrix GTX 980Ti

As gamers, we all know that online is a huge part of our gaming experiences and when it comes to lag, we can all agree with Kimberly "Sweet Brown" Wilkins – ain't nobody got time for that! But it's not just our gaming sessions that can be wrecked by poor networking gear. It's also our favourite streams for Twitch.TV, Netflix (and chill) or the latest episode of Zero Punctuation that, sadly, when using sub-par networking gear, can sound like a bad DJ struggling to drop a track at the right time stamp. It's just not fun. So the ASUS RT-AC88U and RT-AC5300 have been specially developed to deliver premium networking solutions, complete with gaming focused features such as game traffic prioritisation.



RT-AC88U



RT-AC5300

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The **PC PowerPlay** Technical Handbook

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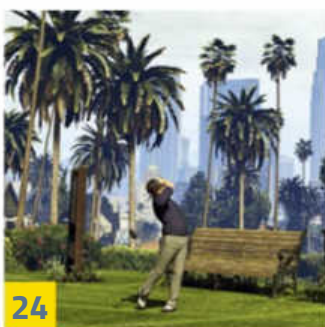
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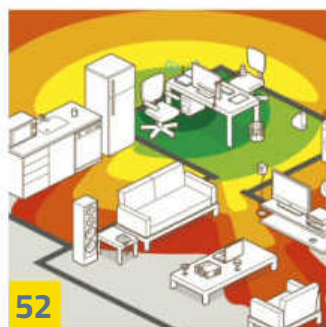
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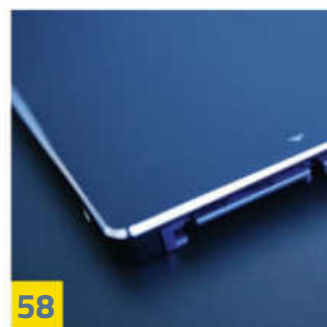
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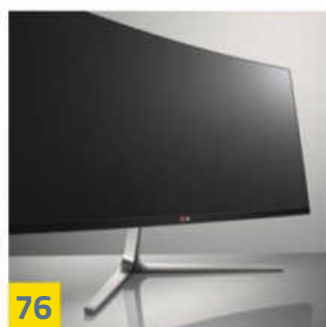
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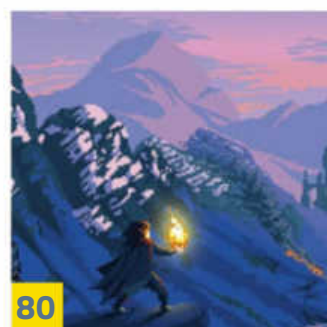
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The GPU wars have begun again





INSTALLING UPDATES

One of the greatest joys, and greatest bugbears of being a PC gamer is fiddling with and tweaking your system to get the most out of it. Sure, sometimes all you want is the plug-and-play ease of use of a console, but such a device can't offer the visceral satisfaction of knowing that you are the one ultimately in charge of how well your system performs. It's always frustrating to have to download new drivers or patches to make things work, but it's always extremely gratifying to know that there's always more performance you can get from your rig. Even better is that feeling you get from diagnosing and solving a problem on your own. If I were a driver (or even had a driver's license) I imagine it's that same enjoyment people get from fixing and tuning their own cars.

This month we're dedicating an entire issue to getting the most out of your PC and games. We've got features on what to overclock and how to do it, what cooling your system realistically needs, what to look for in a mouse, how to properly optimise your speaker of headphone setup to make your games sound their very best and more. Former PCPP editor and current indie game developer Dan Hindes takes a look at the free game development tools around and explains the process of indie development. I had a chat to a number of local and overseas pro gamers about how they made the step up to the pro levels, how they train, found sponsors and whether or not they would consider pro gaming a career. I think we've put together a pretty cracking issue with a little something for everyone. We'll be running some kind of themed special at this time next year as well. If you have any suggestions of what you'd like to see us dedicate an issue to, pop us an email, hit us up on facebook or make a suggestion on the forums. We're all keen to hear what you want.

2016 is shaping up to be a huge year in gaming and tech - we have commercial VR on the very near horizon, bigger and better monitors are rapidly falling in price and starting in February there are some really big games dropping, starting with Far Cry: Primal and going on at a steady pace throughout the year. I can't wait to get stuck in.

Daniel Wilks
Editor
[@drwilkenstein](#)

QUOTES OF THE MONTH



"It's for
overclocking"



"Is the bass rumble
to disguise any
farts?"

"What do you want
me to do with Wilks?"

PC PowerPlay

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PC JARGON BUSTER

CHRIS PIRINA explains the acronyms and initialisms

AGP

The predecessor to PCIe, Accelerated Graphics Ports provided a dedicated pathway for the graphics controller to the system memory. The direct connection allowed for higher clock speeds, and allowed for faster loading of textures by reading directly from system RAM.

ASCII

American Standard Code for Information Interchange is a computer's version of plain text without any specific formatting that all computers can understand. Because computers work solely on numbers, actions and characters are given a numerical value, the ASCII code. ASCII is also known for being the default graphics set of early Rogue-like games.

AMD CU (OR COMPUTE CORES)

A technology that allows the CPU and GPU to speak the same language and share the same memory. Compute Cores are designed to work together in a single process.

APU

Accelerated Processing Unit. These are 64-bit microprocessors designed to act as both a CPU and graphics accelerator on the same chip. Both the PS4 and Xbox One utilise a semi-custom third-generation low-power APU.

CUDA

Compute Unified Device Architecture, when enabled for a GPU, allows for general purpose processing, which allows for simpler parallel processing.

DDR3L

Double data rate type 3, or DDR3, is a form of high bandwidth RAM capable of double the speed of its predecessor DDR2. DDR3L works with lower voltages, meaning lower heat output.



DPI

Dots per Inch, a measurement of mouse sensitivity. The higher your DPI settings, the further the more sensitive the mouse will be to movement. Screen resolution also plays a hand in how DPI affects sensitivity.

ETHERNET

Most common form of local area network (LAN) technology. It utilises a link layer protocol which ensures a connection has established, the data is broken up into frames and that the sent data has been acknowledged on the receiving end.

GDDR5

Based on DDR3 technology, GDDR5 is a high bandwidth type of dynamic random access memory that is designed specifically for use in graphics cards, consoles and high-performance computation.

GPU

Graphics processing units are circuits specially made to accelerate image output in a device, and are utilised in most modern devices such as consoles, phones and computers.

IPC

Instructions per cycle, the average number of instructions the processor executes in a clock cycle, the system used to synchronize all the processors parts and coordinates actions.

LPDDR3

The newest version of DDR3 made with lower standby power usage and slimmer form factor for better use in mobile devices. The lower power output is offset by its inability to handle larger memory arrays found in PC's.

M.2

Internally mounted expansion cards that introduces a new standard for computers and smaller devices like tablets. More flexible than its predecessors, the M.2 connector is suitable for PCIe 3.0 and USB 3.0, the industry standards.

MHZ

Megahertz is the unit of measurement for wave frequency and is commonly used to express microprocessor clock speeds. MHz is equal to one million hertz. GHz (Gigahertz) is equivalent to one thousand million hertz.

PCIe

Peripheral component interconnect express is the latest in bus standards for computers. PCIe is utilised by graphics adapter cards, network interface cards and a slew of other high performance peripherals.

**POLLING**

Polling is the state a computer is in when awaiting for confirmation from an external device. When a command is waiting to be executed, the computer remains polling until the device confirms the action.

PSU

Power supply unit, responsible for powering all the components of a PC. Higher quality PSUs lose less energy to heat when in use.

RAILS

Voltage rails are dedicated rails to sending a single voltage throughout the system. A 3.3v rail will only ever send that voltage, and more taxing tasks require other rails. For example, an ATX PSU has one 3.3 volt rail and one 5 volt rail, each with their own circuitry.

SP/DIF

Sony Philips digital interface is an interface for transmitting digital audio, so as Binary in 0's and 1's which avoids the risk of adding sound, keeping the original recording.



▲ PCIe, not AGP or M.2

▲ A GPU, not a CPU or an APU

SSD

Solid state drive, storage device that has no moving parts, has a higher resistance to physical shock and have faster read/write times, however they are currently far more expensive than the older hard disk drives.

THUNDERBOLT

A powered cable to connect peripherals, while most other cables are passive, relying on external power. This addition speeds up the connection between peripheral and device.

U2

A not so great band that began alright and have been on a steady decline since. People actually paid money to have their free album removed from the iTunes library.

USB

Universal serial bus, the accepted standard for computer peripherals for both communication and power supply. USB 3.1 (latest version) is currently only on par with a single first series thunderbolt

USB TYPE-A

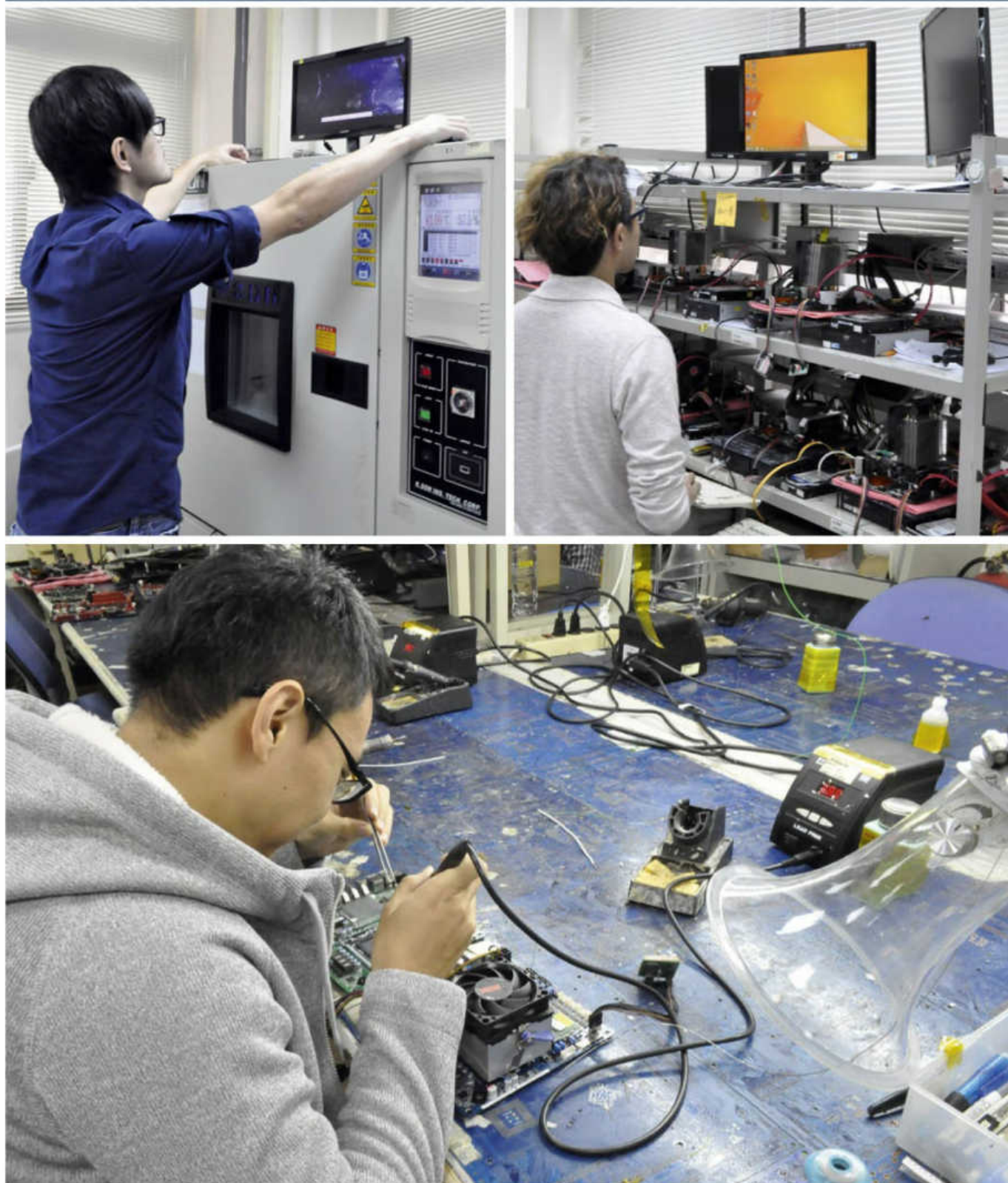
The power end of a cable, usually paired with a type-B or mini/micro usb. This is the most common USB type and is found on many peripherals (keyboard, mouse)

USB TYPE-C

Newest USB type made to replace A/B cables by providing two USB type-C ends in an active, powered cable.

MANUFACTURING SPOTLIGHT

▶ ASROCK



THEIR EVOLUTION



PC GAMING GLOSSARY

CHRIS PIRINA is the king of the jungle

ANTI-POOPSOCKING

Mechanics built into some modern games that seek to discourage day long gaming sessions for health reasons. The Nintendo will often have a "time to take a break" message after an hour of playing for example.

AOE

Area of Effect, an attack that deals damage in a wide area, whether around the character or at a specific location. Term used in MOBAs, MMOs, turn based RPGs

BUFFER

'Storing' inputs when attacking isn't possible, like the quarter circle for a Hadouken, and then hitting the attack button when attacking is possible to immediately fire the projectile/ use the attack. Used also in speedrunning to execute commands on the first possible frame.

CROSS UP

A way of cancelling out an opponent's defence in fighting games by mixing low, high and overhead attacks that all require different blocks. A successful cross up will hit an opponent into hitstun, opening a combo.

FLEX

Role in competitive MOBA for a player, when a team already has a balanced comp of tank/ damage/support, the flex is allowed to freely counter-pick whatever is necessary against the enemy team

FRAME DATA

The specifics of an attack, applicable to all fighting games. Frame data looks at start up frames (time between hitting a button and attacking), the actual hit, and recovery (time when you can't do anything) measured in frames per second.

HITBOX

An invisible rectangle that layers over a part of a character model that dictates what will collide with other objects. Hitboxes are the attack portion of a character.

HITSTUN

Short period after an attack when the opponent cannot react, even when blocking. This is what allows for comboing in fighting games, by chaining attacks with faster recovery than the hitstun



HURTBOX

While a hitbox is what will hit another player during an attack, a hurtbox is where you can be attacked. Hurtboxes are the vulnerable parts of a character

JUNGLING

Jungle is the space between lanes in MOBAs, which contain mercenary camps that will give exp, gold, and lane presence. Jungling refers to the management of this space, usually left to a specialised character.

PEELING

Using attacks and character placement to pull an opponent away from their team during a fight in MOBAs to allow for easier takedowns. Most commonly done by tankier characters against support roles.

POKING

In fighting games, pokes are fast attacks that bait an opponent into using a slower attack on your block, opening up a combo. In MOBAs, poking is throwing basic attacks at an opposing team to bait one of them out, or just to get information.

POOPSOCKING

Defecating in a sock to allow for longer gaming sessions, part of the dedicated MMO player stereotype.

RESET

Many fighting games have diminishing returns in combos, resetting allows the damage to return to normal. When a combo has been dropped or finished naturally, resetting will

come from correctly guessing the opponents next move and reacting.

SCRIMMING

Competitive game practice match between two opposing clans or teams depending on the game.

SHOTO

Type of character popularised, and named for, Ryu from Street Fighter 2. Shoto characters will have a horizontal fireball (hadoken), an uppercut (shoryuken) and a movement attack (tatsunami senpukyaku)

SPLIT PUSH

Having a character intentionally split from a team fight when pushing to work on another lane with minions or mercenaries. Monopolises on the enemy team being distracted by the first bigger push.

STARTUP INVINCIBILITY

Invulnerable state given to a character in a fighting game for certain attacks during a startup animation. Not all animations grant invincibility in return for compressed or strange hurtboxes.

SUPER ARMOUR

State that certain attacks in fighting games grant that allows a character to absorb an attack before taking damage or being stunned.

TECHING

Hitting a button when knocked to the ground for immediate recovery. In 2d fighters the options are generally forward roll, back roll, jump and wakeup attack.

OUR EXTINCTION



XCOM 2

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GAMING CPUS AND THE RISE OF DX12

BENNETT RING has seen the future of PC gaming

We often refer to the holy trinity of gaming performance here at PC PowerPlay, which pertains to the three major components within your system that will impact on frame rates. Your graphics card is obviously of paramount importance, as it's tasked with the final steps of the rendering process, and the better your GPU the higher the resolution, anti-aliasing and other graphical effects you can run. System memory is also key, as if the game runs out of memory it'll have to fetch data from the sluggish hard drive, causing stuttering and slow downs. The final piece of the performance pie is one that is often overlooked – the Central Processing Unit, or CPU. The following article will explain how certain CPU specifications impact game performance, and how the introduction of DX12 is going to unleash its power.

KEY CPU TERMS

Your CPU is really the beating heart of your system, and as such it's responsible for running the dozens of processes that Windows requires. However, it's also incredibly important when gaming, and here are the various specifications that can impact game performance.

Frequency

About a decade ago, frequency was king. This is the speed at which the CPU executes operations, and the faster the frequency, the better your games will. This is measured in MHz or GHz (the latter is 1000MHz). Back in the early 2000s, the competition between AMD and Intel was all about which chips could get to the highest frequency. Unfortunately CPUs hit a wall when it comes to frequency, as the faster they run, the hotter they get. This is why we've seen Intel's CPUs plateau around the 4GHz mark for around five years. Instead, they're now focusing on better IPC and more cores.



At GDC earlier this year Microsoft showed off Forza Motorsport 5 utilizing DirectX 12

Instructions per Cycle (IPC)

This refers to how many instructions are executed per clock cycle, and the more it can handle, the better the CPU performs. Back in the early days of PC gaming, both AMD and Intel had very similar IPC rates, which is why frequency became so important. However, when the Pentium 4 was launched it had a significantly lower IPC than AMD chips. When comparing the Pentium 4 against an AMD chip running at the same frequency, the AMD chip ran rings around the Pentium 4. It was only when Intel moved to the Core design that it regained the lead in IPC. Today AMD has a slight lead in frequency, but a rather large deficit in IPC, which is why Intel chips are significantly better performers in games.

CPU Core

Today's CPU's are comprised of between two and eight cores. Each core is basically a processor unto itself, though the multiple cores do share some overall resources such as the cache. The reason we have multiple CPU cores today is that the quest to increase CPU frequency hit a brick – or should we say thermal – wall back in the mid-2000s. Intel and AMD realised they couldn't keep increasing CPU frequency without major heat issues, so their solution was to double up on the number of CPU cores. This sounds all well and good, but the issue is that software development for the previous thirty years had focused on single core coding. The move to multiple core programming, also known as multi-threaded programming, was much trickier than anybody envisaged, and it has taken ten years for game developers to finally get their heads around it. Having said that, it's rare for a game to make use of more than

under DX11 the PC could only churn out around 10,000 draw calls per frame, and even then only by talented coders

four cores today, which is why AMD's octa-cored chips don't have a performance benefit over Intel's quad-cored chips when it comes to most games.

Cache

The CPU's cache is extremely fast memory embedded into the chip. The more cache present, the faster the processor can fetch instructions, and more is always better as it also impacts on the IPC of the chip. However, compared to IPC and Frequency, cache is one of the lesser determinants of speed. Note that there are several different types of cache present on the CPU: L1, L2, L3 and L4.

Hyper-Threading

This Intel-proprietary technology basically allows a single CPU core to act like two, and in the best possible circumstances allows each core to run two simultaneous streams of instructions, doubling performance. This is most obvious when running non-gaming applications, but there's a huge amount of debate about whether Hyper-Threading is good or bad for game performance. Unfortunately the answer isn't simple, as it depends entirely on the game itself. Numerous tests have shown that some games prefer Hyper-Threading, such as Skyrim, while others can actually see a



performance decrease, such as ARMA3. Generally speaking though, as games are becoming more multi-threaded, Hyper-Threading should have a slightly positive impact on performance, though nowhere near a doubling of performance. And when there is a performance decrease, it's so small that the benefits of Hyper-Threading in all other usage scenarios mean it's probably worth keeping on.

DIRECTX 12 IS A GAME CHANGER FOR CPU PERFORMANCE.

While our PCs generally run rings around the consoles when it comes to performance, there's one area where consoles have a huge advantage – draw calls. Without spending 30 pages explaining exactly how graphics are made, basically speaking whenever a scene is to be rendered, the CPU has to first simulate the base model of the scene, and then send off instructions to the GPU to finally draw this scene. The more detailed each scene, the more draw calls the CPU needs to make. Consoles have a huge advantage here, as game developers can “code to the metal”. That is, they know exactly what hardware will be within each platform, so they can extract the maximum possible draw calls out of the CPU. This is why Assassin's Creed Unity on the consoles could pump out around 50,000 draw calls per frame.

But the PC is a very different beast to the consoles. Developers have to take into account dozens of different CPU types and speeds, so they have to write to the API, or Application Programming Interface, which in the case of Windows is DirectX. It makes coding for PC much simpler, but DX11 and its predecessors had one major issue – they required a lot of CPU time to decode the game's instructions into a format that each CPU type could understand. As a result, under DX11 the PC could only churn out around 10,000 draw calls per frame, and even then only by talented coders. Sure, there are tricks and techniques to help get around this issue, but the PC was still at a severe disadvantage compared to consoles. It's no wonder that Assassin's Creed Unity was and still is plagued by performance issues on the PC.

DirectX 12 promises to solve this issue once and for all. It's known as a low-level API, which means it targets the hardware much more efficiently than earlier APIs. This in turn results in a HUGE increase in the number of draw calls possible. How much of an increase? Well, luckily we have 3DMark's API Overhead Feature Test.

THE DX12 BENCHMARK – 3DMARK

According to Futuremark, creators of the API test in 3DMark, the test, “measures API performance by making a steadily increasing number of draw calls. The result of the test is



the maximum number of draw calls per second achieved by each API before the frame rate drops below 30 fps.” It ensures the API is the bottleneck and not the GPU, by drawing a scene with a huge number of individual buildings that don't have any lighting or detailed shader effects. Note that to run it you'll need a PC with Windows 10, along with a DX12 compatible graphics card. We ran it on a machine with an Nvidia Geforce Gtx 970 and Intel i7 2700k processor, and as you can see from the following graph, the results were astonishing.

DRAW CALLS PER SECOND



Yep, you're looking at roughly a ten-fold increase in draw call performance. It's no wonder Microsoft and game developers are so excited about the introduction of DirectX 12. However, we have to point out that these numbers are theoretical – graphics

▲ DX12 is capable of producing far more draw calls per frame at a consistently higher framerate

experts believe that in-game graphic fidelity will probably be able to double as a result of running DX12 on identical hardware. Still, that's a huge leap in detail; imagine Star Wars Battlefront with visuals twice as detailed.

MORE CORES FOR YOU

One reason AMD is super excited about DirectX 12 is its improved ability to leverage multiple CPU cores. In the past, developers had to code their games specifically to take advantage of many CPU cores, but DirectX 12 takes much of that work out of the developer's hands, instead intelligently dividing the game's threads amongst as many cores as the CPU has. Early benchmarks have shown AMD's octa-cored processors seeing massive improvements in performance under DX12, to the point where they might even have a healthy lead on Intel. So here's to DX12, and a reboot of the CPU wars.



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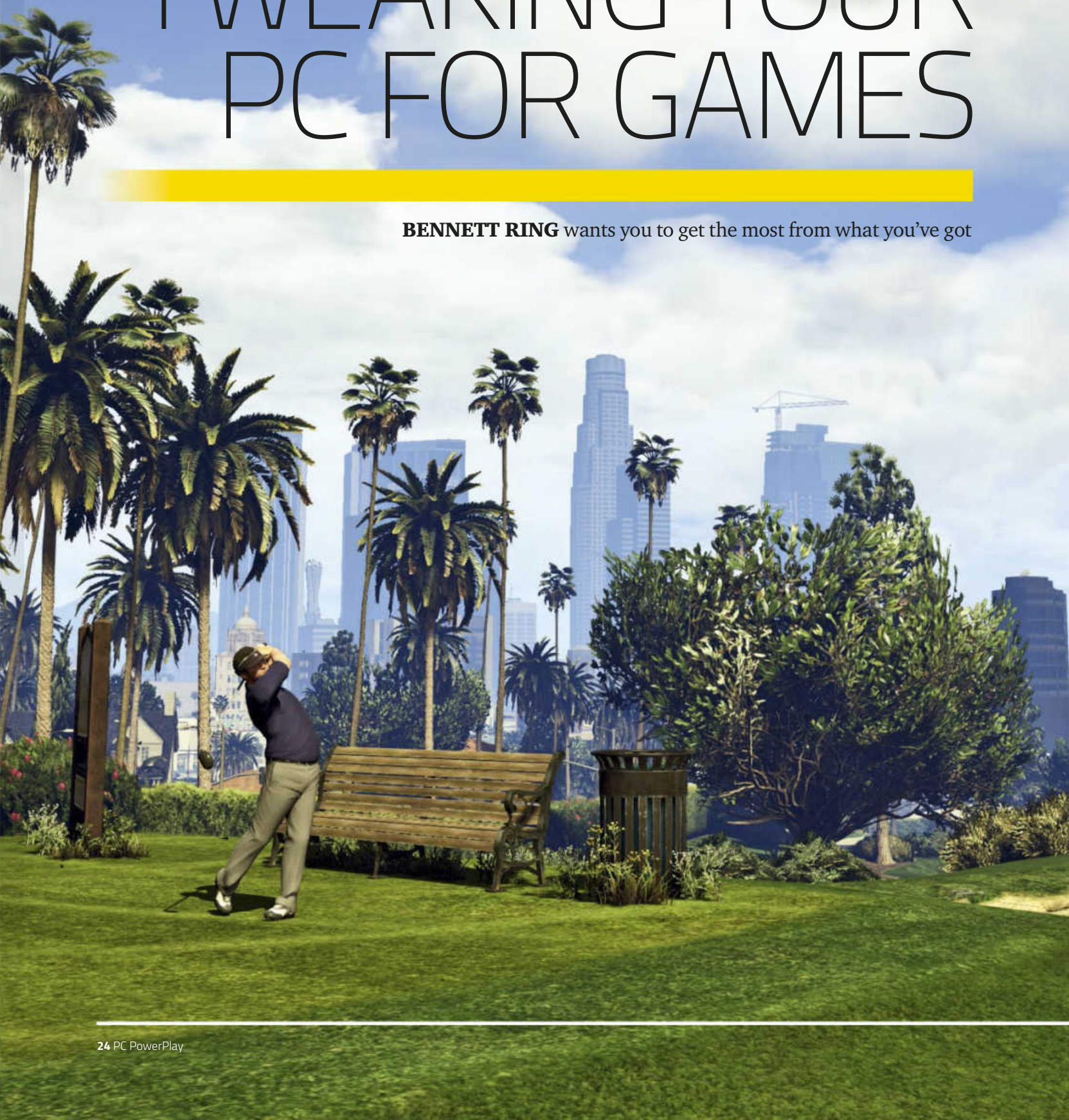


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PERFORMANCE TWEAKING YOUR PC FOR GAMES

BENNETT RING wants you to get the most from what you've got



GIVE YOUR PC A BLOWJOB

Most of the hot bits inside your PC are cooled by little spinning blades otherwise known as fans. There's usually one on your CPU, your graphics card, inside your PSU, on the front and rear of your case, and possibly even on your motherboard. The problem is that these make damn fine dust-collectors, and as they clog up they stop working well. When they're not working, heat becomes a problem and your hardware could automatically slow down to stop it burning out. This is especially a problem if you've got fur-covered friends in the house or you smoke whilst gaming. The solution is to buy a can of compressed air and to give all of your fans a good blow every six months or so. A can will set you back around five bucks, though you can also buy a high-speed air blower specifically designed for electronics cleaning for \$100 or so. One thing to remember if you're using the canned variety is to *always* keep the can perfectly upright, otherwise moisture can be sprayed from the can. Not only will removing the dust ensure your PC remains cool and fast, you'll be amazed at how much quieter it runs.



▲ Making sure your drivers are always up to date is one of the surest and easiest ways to optimise performance

DRIVING MISS LAZY

It continually boggles us how often friends and family can't get games to run, simply because they're too lazy to update their graphics drivers. It's crucial to keep your GPU's drivers up to date, so always check for new drivers on a weekly or fortnightly basis – you'll find Nvidia and AMD usually release a major new set whenever a big game is released. It's not uncommon to see a 20% performance boost in a game simply from new GPU drivers. Your motherboard also uses chipset drivers, though they tend not to be updated anywhere near as regularly. Still, it's worth hitting your mobo maker's site every six months or so to grab new drivers for the motherboard chipset, onboard LAN and audio, and any storage devices. Finally, all of your other peripherals such as mice and sound cards usually need drivers too, so it's worth checking for new ones every few months.

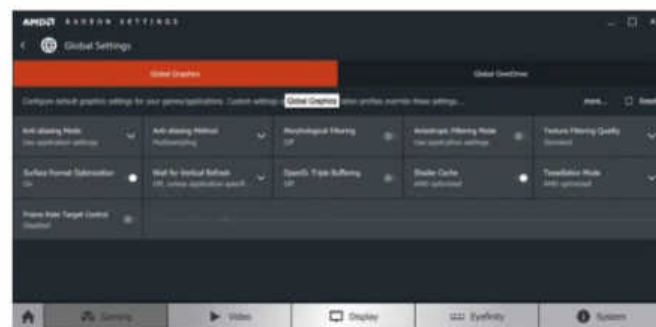
Now that we've shown you a few basic maintenance tips to keep your PC running sprightly, let's look at the control panels of both AMD and Nvidia to see what options are there for improving game performance. This is especially timely given that AMD has just overhauled its entire graphics control panel with the release of the Radeon Software Crimson Edition.

AMD RADEON SOFTWARE CRIMSON EDITION

The day before this article was written, AMD released the biggest graphics control panel and driver revision in many years. It's called Radeon Software Crimson Edition, and we love it. For starters, it fires up in just 0.6 seconds compared to 8 seconds for the last version – to do so, simply right click on your desktop and select AMD Radeon Settings. You'll then see this sexy screen:



The most important tab here is the Gaming one, and clicking on this reveals the new game tweaking interface. From here you can select Global Settings, which applies all graphics settings to every game, or you can create a custom profile per game. If you do choose to create custom profiles, you'll need to set all of the following options for each individual game profile. For our guide we're going to focus on Global Settings to deliver the best performance and visuals across all of your games.



ANTIALIASING MODE AND METHOD:

You can leave your game to handle the antialiasing settings, or you can override it from these two settings. The Mode will select whether to use the game's antialiasing, enhance the game's antialiasing (this rarely works though) or to override it entirely. If you choose either of the latter two options, you can then select the antialiasing method. Multisampling (MSAA) is the traditional method used by games, while Supersampling (SSAA) is a much more powerful, demanding method that will clean up more jaggies, but can cause a severe performance hit. Adaptive multisampling sits somewhere between the two in terms of quality and performance hit.

MORPHOLOGICAL FILTERING

This is basically a method of antialiasing that is applied after the image is rendered, and not during like traditional antialiasing. This means it's great for games that don't support traditional antialiasing, but it can introduce some graphical errors such as blurred textures. It's also

rather performance sapping, moreso than MSAA, but less than SSAA. Only enable this if your game doesn't have native support for antialiasing.

ANISOTROPIC FILTERING LEVEL

Want a fantastic free way to improve your game's appearance without a performance hit? Anisotropic filtering basically sharpens the appearance of textures, especially over distance, and it can be enabled with a minimal performance hit of one or two percent. We suggest cranking this to x16. Interestingly enough, it turns out that Anisotropic filtering is a major performance hit on the consoles due to the way their CPU and GPU share memory. Scratch up another win for PC gaming.

SURFACE FORMAT OPTIMISATION

This cryptically named setting apparently asks the driver to change some rendering surface formats, which should result in improved performance without any quality decrease. Yeah, it sounds confusing to us too, so just leave it on unless you hear of any specific game-related issues.

WAIT FOR VERTICAL REFRESH

This is the basic control for enabling V-Sync. Leave it on to lock your framerate to your display's refresh rate, and you won't have to endure torn frames. However, it can decrease performance massively, and also introduce stutter. Disable it to maximise framerates and lower latency, at the cost of torn frames.

OPENGL TRIPLE BUFFERING

This setting only works in games that use the OpenGL API, which is relatively few these days (think Id Tech games). It uses some clever programming to increase the framerate and lower latency while V-sync is engaged. Always leave this on.

SHADER CACHE

This is a brand new option found in the Crimson software, and it allows the drivers to "transparently cache compiled game shader routines, reusing them rather than recompiling them each time they're used." Apparently DirectX doesn't do this, and enabling this setting has benefits in two scenarios. Firstly, games that preload lots of shader compilations can now simply reuse those shaders, which should help on systems with slower (cough AMD cough) CPUs. Secondly, games that have an especially large amount of assets which compile shaders on the fly can cause stuttering – this new setting should reduce said stuttering. We'd suggest ensuring this setting is enabled as a result, as it can have significant performance improvements, and AMD claims it's noticeable in Battlefield.

TESSELLATION MODE

Tessellation is a method of increasing the triangle count in rendered scenes without dramatically impacting performance. In other words, it gives you a richer, more detailed world without hurting your frame rate. Well, that's the theory at least. AMD cards have a relatively weak tessellation engine compared to NVIDIA cards, so AMD includes this setting to give them a leg up. AMD claims many games that use tessellation overdo it, adding too much detail with no visual benefit. Enabling the AMD Optimised setting here reduces the amount of tessellation so that AMD performance doesn't suffer, but the rendered scene should still look more detailed than without any tessellation.

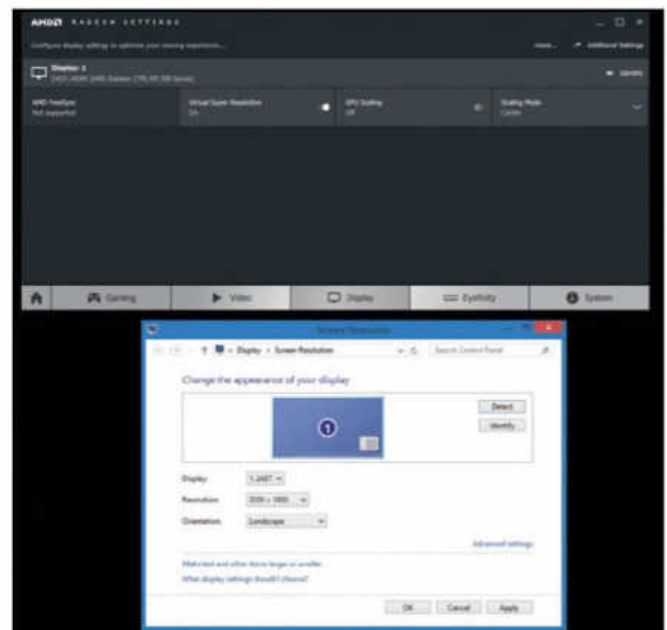


FRAME RATE TARGET CONTROL

This is another setting that has been massively updated in Crimson. It does exactly what it says on the tin – limits the game to run at the framerate decided by the slider next to it. The benefit of this is that a gamer can limit the game to run at the native refresh rate of their display, say 60Hz or 60fps, and get the benefits of V-sync without the performance hit or lag. The major improvement in Crimson is the range of framerates now supported – it used to only be between 55 and 59fps, but now goes all the way from 30fps up to 200fps.

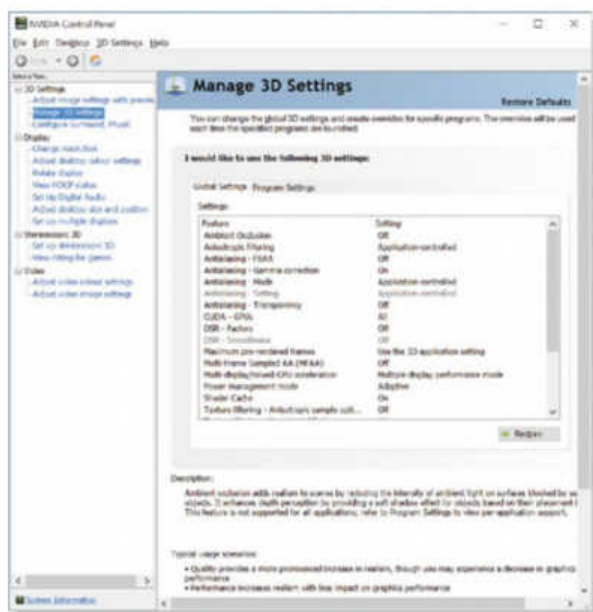
VIRTUAL SUPER RESOLUTION

The last setting we're going to discuss is AMD's take on downsampling, called VSR for short, which is the process of running games at a resolution higher than that supported by the display. For example, using a 1920 x 1080 monitor, enabling VSR allows the user to set the display as high as 3200 x 1800. This is a fantastic way of cleaning up jaggies in games that don't support antialiasing, but obviously comes with a major performance hit, depending on how high you run your resolution. To enable it, go to the home page of Crimson, then select the Display tab at the bottom. Turn Virtual Super Resolution on, and you'll now see a range of higher resolutions available in your games.



AND IN THE GREEN CORNER

Now that we've explained the main game-related features of AMD's new Crimson driver interface, it's time to check out Nvidia's Control Panel. We have to say that in the past we favoured Nvidia's control panel for its speedy loading and relatively clean layout, but AMD's new Crimson interface has leapfrogged Nvidia here – it's faster and sexier. Having said that, one feature we LOVE about Nvidia's control panel is that it gives the user a basic text description of each setting. Let's check out which settings are unique to Nvidia products – note that we won't cover settings that aren't game-related. To access the control panel, right click the desktop and select NVIDIA Control Panel. Then select the Manage 3D settings option to see the following screen:



▲ The Nvidia control panel isn't the most glamorous thing, but it does offer good text descriptions for settings

AMBIENT OCCLUSION

Invented by ILM for use in the film Pearl Harbour, Ambient Occlusion eventually found its way into PC games since 2007's Crysis. It is a method of applying light and shadows to a model that mimics the way the real world works. There are three settings – Off disables it, Performance applies a low-performance hit version of AO, while Quality applies the most detailed, but most performance-sapping, version of AO. It's worth experimenting to see which setting you like most. Those with high-end GPUs can crank it to Quality.

ANISOTROPIC FILTERING

Exactly the same as AMD's setting, this should be set to x16.

ANTIALIASING – FXAA

FXAA stands for Fast Approximate Antialiasing, and is a method of killing jaggies that requires far fewer GPU cycles than traditional MSAA. It's also compatible with certain games where traditional MSAA doesn't work. However, it's not quite as good as MSAA at removing jaggies, and can introduce some blurring to textures. We suggest sticking with MSAA if you have the horsepower, and only use FXAA if you find MSAA slows your games down too much. You can also try enabling both FXAA and MSAA at the same time to really wipe out aliasing.

ANTIALIASING – GAMMA CORRECTION

Leave this setting on, as it brings a slight image quality improvement to traditional antialiasing for no performance hit.

ANTIALIASING – MODE

This is the same settings as AMD's.

ANTIALIASING – SETTING

If you select "Override any application setting" in the Antialiasing – Mode field, you'll now be able to set the level of antialiasing in this box. There are three values – x2, x4 and x8. As they increase, the level of antialiasing improves, but performance drops drastically at the higher values. Experiment with this setting.

ANTIALIASING – TRANSPARENCY

Ever noticed a wire fence in a game? Each individual wire probably isn't made up from polygons, but instead is a transparent texture with the wires drawn on it. This means traditional antialiasing won't smoothen out those wires, which is where this setting comes in. Enabling it will look for straight lines in transparent textures, and antialias them. Be aware that this comes at a performance cost on slower GPUs.

CUDA – GPUS

For the purposes of gaming, ignore this setting. It's really only relevant for applications that use CUDA acceleration, which are usually scientific or mathematic in nature.

DSR – FACTORS

DSR stands for Dynamic Super Resolution, and is Nvidia's take on downsampling. This setting allows you to set which resolutions you want to open up – we suggest ticking every box in the drop down menu to make every downsampled resolution available.

DSR – SMOOTHNESS

This option is only available if you check the boxes in the previous setting. When using a DSR resolution that doesn't fit your native resolution well – say, a DSR of 2560 x 1440 on a 1920 x 1080 display – there can be some sparkling or noise found in the final image. DSR smoothness irons this out, but at high values can lead to an overly soft image. We've found 30 to 40 percent is a good value to keep the image crisp.

MAXIMUM PRE-RENDERED FRAMES

NVIDIA has made a big song and dance about this recently, as lowering the value can improve input latency in MOBAs. This option controls the number of frames the CPU prepares in advanced of being rendered by the GPU. Higher values result in smoother, yet laggy play. However, it can also cause extremely weird stuttering in most games if it's set too low, so we highly suggest leaving this as is, unless your game specifically runs well with it set to a low value, such as DOTA 2 or LoL.

MULTI-FRAME SAMPLE AA (MFAA)

Nvidia sure does love its proprietary antialiasing techniques, and MFAA is the latest one they've unveiled. It's only supported on Maxwell GPU-based cards. It's another method of antialiasing that delivers image quality that rivals MSAA, but with a lower performance hit, up to 30% faster in fact. It's not quite as good as MSAA, but you'll be hard pressed to pick the difference, so we suggest enabling this if your hardware supports it.





SHADER CACHE

You guessed it, exactly the same as the AMD setting. Nvidia implemented it first though...

TEXTURE FILTERING – ANISOTROPIC SAMPLE OPTIMISATION

NVIDIA should remove this setting, as we always suggest setting it to off, as this setting aims to increase the performance when anisotropic filtering is applied. The thing is, anisotropic filtering has such a low performance hit that there's really no need to optimise it.

TEXTURE FILTERING – NEGATIVE LOD BIAS

This is another setting that we think NVIDIA should cancel, as it's now seemingly obsolete. The weird thing is that the default option is the worst of the two, as it delivers slightly better performance at the cost of aliasing. Set this to clamped and forget it ever existed.

TEXTURE FILTERING – QUALITY

The term texture filtering replies to a range of anisotropic and trilinear filtering optimisations that are applied to textures in your games. Setting this to High Performance applies the maximum level of these optimisations to deliver better performance at the cost of texture clarity. Change it to High Quality and all those optimisations will be disabled, slightly lowering performance in return for crisp, clear textures. Unlike normal anisotropic filtering options, this can have a big impact on performance. Try each setting until you find the right level for your GPU.

TEXTURE FILTERING – TRILINEAR OPTIMISATION

Very similar to texture filtering, this determines whether or not to apply bilinear filtering when trilinear is not necessary. Leave this on if you have an old GPU, but turn it off if you're running something decent.

TRIPLE BUFFERING

Use this if you've enabled V-sync, as it will help to prevent any FPS loss caused when your GPU's framerate drops below the refresh rate of your display. However, if you've got V-sync disabled, turn this off, as it eats up memory.

VERTICAL SYNC

Identical to the AMD "Wait for Vertical Refresh" setting, but with two extra options – Adaptive and Adaptive (half refresh rate). Adaptive leaves V-sync disabled until the framerate of your game hits the refresh rate of your display, removing the lag of V-sync until it's really needed. Setting it to half refresh rate will tie your framerate to exactly half that of your display.

Phew, we didn't realise just how many new options are to be found in the Nvidia and AMD control panels until we started this guide, so hopefully we've explained the key ones. Just remember that finding the optimal settings is all about trial and error, so only adjust one setting at a time to see exactly what impact it has on your games. 🖥️

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WHAT TO LOOK FOR IN A MOUSE

Your mouse is the main point of interaction between you and the many virtual worlds you want to explore – **DAVID HOLLINGWORTH** is here to help you get the right rodent for your needs.



▲ The Roccat Kova features a 3500 DPI optical sensor hardware boosted to 7000 DPI

It's actually kind of odd that possibly the cheapest piece of kit in your build is the one you rely upon the most, but that's the nature of the machine interface that has evolved around the PC. CPUs and video cards are still the big drivers of what your PC can do, but they're out of the way. Your mouse, though, is front and centre, and if you've ever used a friend's PC, or sat down to a strange system at a convention, the time it takes to get used to a new mouse can be catastrophic – using one that is actively bad, or at the least not designed for how you game, can be even worse.

But what makes a good mouse, when it's such a deeply personal computing peripheral? Well, to help you make the right choice, there are some basic things to look for.

MOUSE TECH

To start with, it doesn't hurt to know how your mouse works, and the most important part of your mouse is its tracking mechanism. Once upon mechanical or ball mouse, with a little rubber ball that interacted with two wired up rollers, where the king of the hill, but these days they're pretty much obsolete – and thank the gaming Gods, too, because cleaning them was both a hassle, and kind of gross!

Now, you've got two dominant tracking mechanisms – optical, which is admittedly going out of style, and laser.

Optical trackers have no moving parts, which is a plus on the reliability side, and track movement via the reflected pattern of an LED light. As it moves across a surface, the changing light is converted into tracking data, and your cursor – or gun-sight – moves across the screen.

Laser mice use a laser instead of an LED, but the principle is the same. However, the more coherent laser beam offer much more accurate tracking, delivering not only precision, but also smoother motion. Unsurprisingly, laser mice are far and away the better option for gamers. You can still occasionally find dual LED/Laser mice, and Logitech even has a dual laser mouse. But, if you stick with a laser sensor, it's hard to go wrong.

Gaming mouse generally come with a range of DPI measurements, or 'dots per inch', which measures the mouse's sensitivity. As a rule, the higher the better, but some games – like MOBAs and RTS titles such as a StarCraft, really benefit more from a high DPI.

THE BUTTON, THE BUTTON, WHO'S GOT THE BUTTON?

The next most important thing to consider is what kind of button arrangement you require, which generally comes down to what kind of games you'll be playing. A lot mouse manufacturers have a general split between

button-heavy MMO mice, and simpler, but faster-responding, mice designed for shooters. Games like StarCraft and MOBAs often fall under the latter type, as well.


Dedicated mice for dedicated games may sound cool, but the truth is that most of us play a wide range of games. We might log onto Warcraft for a dungeon raid on Saturday afternoon, but spend a fifteen minutes each morning with World of Warships (also, it seems we have a passion for "World of..." games).

You could have different mice for each game, but for the average gamer, we'd recommend something that your classic left and right buttons, a button on the scroll wheel, and that's it. Side-buttons can be useful, but depending on your grip, they can also get in the way – and you don't want random mouse-clicks in the middle of a serious online beat-down.

If you are a one-game guy, or you're looking for a solution to pro-level gaming, by all means specialise.


ERGONOMICS

Here's a topic where there is no catch-all answer. Just like our hands are all individual, the perfect mouse for one gamer could be hell for another. If you're serious about mice, we'd recommend getting hands-on time with anything you're looking at buying. Consider how you grip your mouse – do you rest your palm and hand over it, or only grasp it in claw grip? Do you like to pick up your mouse and scoot it back and forth, or are you fond of large, expansive gestures? The answer to these questions inform everything from placement of rubber grips, to size, even to the smoothness of the mice's silicon feet.

There is almost certainly a perfect mouse out there for you, but finding it will take a little more reading the latest benchmarks. 



► The Razer mamba RGB features a staggering 16000 DPI optical sensor

Now, you've got two dominant tracking mechanisms – optical, which is admittedly going out of style, and laser. 



► The Cougar 500m has a 4000 DPI sensor and 1000Hz polling rate

► The Mionix Castor boasts a 10000 DPI sensor with no hardware acceleration

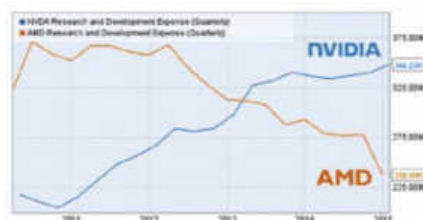


THE DIFFERENCES BETWEEN AMD AND NVIDIA GPUS

BENNETT RING is a survivor of the GPU wars

Ok, so I've got 500 words to describe the difference between AMD and NVIDIA GPUs, but to effectively do that would require a degree in electronic engineering (something I do not have), computer science (ok, got lucky there) and 400 pages of highly boring schematic diagrams of incredibly complex microarchitectures. So instead I'm going to focus on key differences in their approaches to products of late, and how they ended up here.

Let's start with noting how much each company is worth. At the time of writing Nvidia was valued at around US\$10 billion, while AMD is worth around the US\$2 billion mark. Bear in mind that AMD paid US\$5.6 billion to acquire ATI ten years ago, so it's easy to see that the company's fortunes have not been great. Trust me, as somebody who recommended a friend buy AMD stocks during the time of the ATI deal, I know how far those stocks plummeted. I still feel bad. And a company with less money has less resources for Research and Development. This graph sums up perfectly how the two companies differ in terms of that:



Considering the worth of the company, as a proportion of its value AMD is to be respected for spending so much on R&D, but it's also spreading that out amongst its CPU and APU business. Meanwhile NVIDIA is spending almost 50% more than NVIDIA, and we can assume that more of that is going into GPU research, even though NVIDIA is getting into other products.

So when we look at the range of new products from Nvidia, it's no surprise to see that most of them are based on its excellent Maxwell architecture, released in 2014 to widespread acclaim for its excellent performance and low power and thermal requirements. In fact, every single product in the GTX 9XX

▼ Nvidia's Titan series is the current king of speed

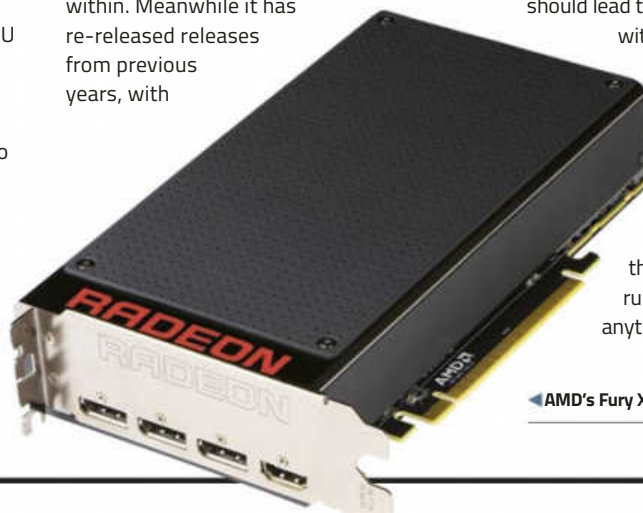


series is based on this chip, from the lowly GTX 950 up to the incredible Titan X. As a general rule, these cards tend to offer the best performance in the performance to elite-range of products, while all of the products are renowned for better thermal efficiency.

AMD's approach has been very different. Its flagship product only recently released in the form of the Fury X just recently, and so far the company only has a handful of products based on the Fiji chip used within. Meanwhile it has re-released releases from previous years, with

some of their products using tech from three years ago. Yet it's a strategy that appears to have worked in the entry-level to mid-range, where their reliance upon mature, proven designs allows them to churn out affordable products that perform well, although often operate at rather high temps.

Next year is set to be a game-changer though, with Nvidia and AMD finally moving to a 14nm manufacturing process after being stuck on 28nm for the past several years. This should lead to an exponential jump in power, with NVIDIA claiming its new Pascal chip will have double the transistors of Maxwell, a rather insane 17 billion. Meanwhile AMD is claiming its upcoming Greenland chip will have 18 billion! Whatever happens, we can only hope that AMD stays in the game, as having one green giant ruling the graphics world can't lead to anything good. 🚩



◀ AMD's Fury X uses the new Fiji chip

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STRAP IT TO THE BENCH

BENNETT RING
loves big numbers
and bar graphs

The humble benchmark is the foundation on which all tech reviews are built. They're the bedrock that allows us to factually state whether one piece of hardware is objectively faster than another – there's none of this nonsense found in game reviews where people's *opinions* and *tastes* influence the final score. But benchmarks can also be used for so much more; isolating hardware problems when your PC starts conking out more often than a narcoleptic on Valium; testing whether your new overclock is going to kill your PC, and giving you bragging rights over the other nerds who frequent that hardware forum you spend far too much time on.

But which benchmarks should you use for each of these scenarios? Well, PCPP's tech writers spend at least 68% of their waking hours in front of these bloody things, so we're going to share our favourite ones with you, and point out their pros and cons.

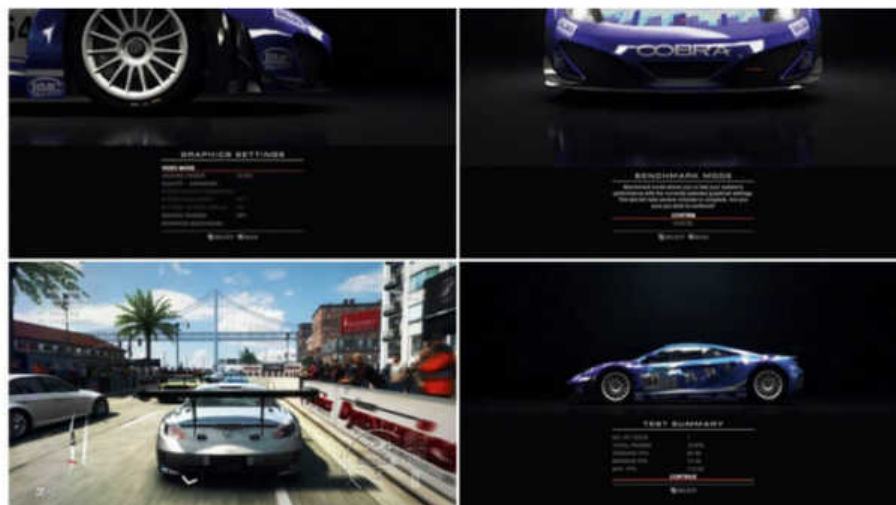
BENCHING FOR GAME PERFORMANCE

You're here to build a better PC for playing games, right? Well then obviously the best way to test the overall performance of your system is with games, duh? The only problem is that most games don't have a built in benchmarking routine. Sure, you can fire up Battlefield for 10 minutes with FRAPS recording in the background, but every time you try to recreate that 10-minute play session, something different will happen – an X-wing that lived the first time might crash in front of you, dragging down your framerate with its billowing smoke effects. This is why we always use games that include a pre-scripted game demo or benchmark feature. Unfortunately, this does limit the number of games we can use, but currently we have four favourites here at PCPP. Bear in mind we've been using these for about a year now, so will probably upgrade to a new benchmark suite soon.

They're the bedrock that allows us to factually state whether one piece of hardware is objectively faster than another

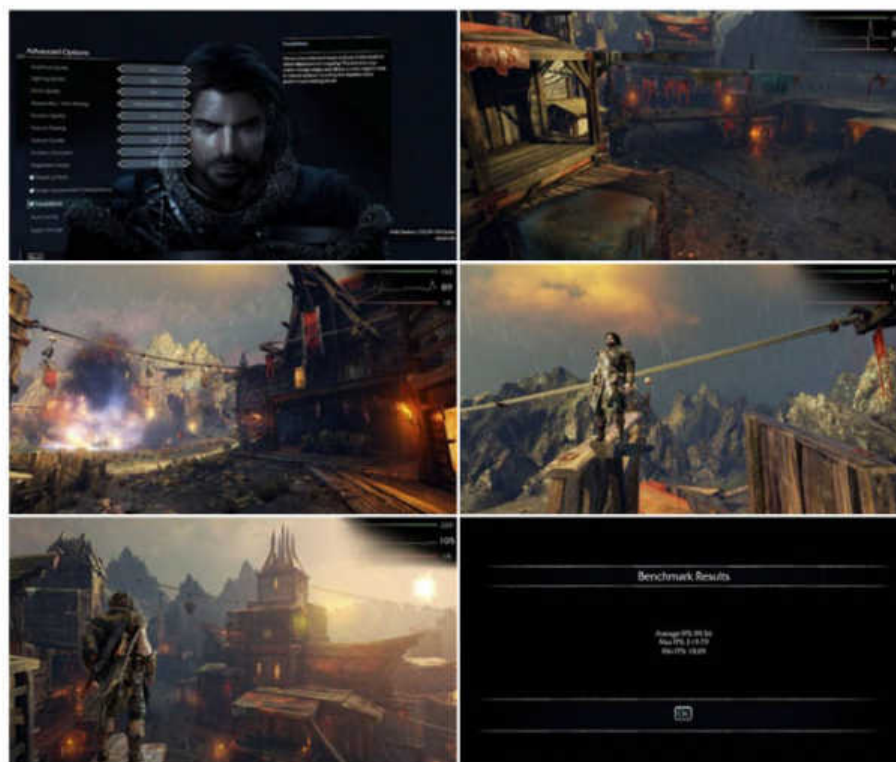
GRID AUTOSPORT

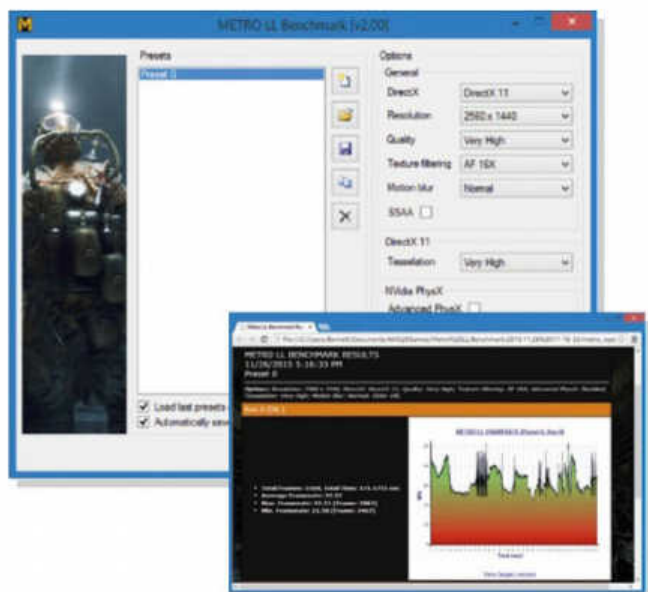
We love this benchmark because it allows us to scale the graphics from a lowly 1280 x 720 with low detail settings, perfect for an entry-level GPU, all the way up to 4K resolution with crazy reflections and antialiasing, which will bring a Gtx 980 Ti crying to its knees. We've found the results to be highly repeatable, and it even spits out the minimum, average and maximum frame rates at the end. Too easy right? The only issue with Grid Autosport is that it's getting a little old in tech terms, so is quite a simple test for most hardware. It's also more dependent on CPUs than GPUs these days, except at the very low end of the graphics card market.



SHADOW OF MORDOR

This is the mid-ground benchmark in our suite, as it features tessellation, ambient occlusion and order independent transparency, settings that are quite modern, not to mention taxing. Like all of our tests, it doesn't favour AMD or NVIDIA in any drastic way. Our only concern with this benchmark is that it doesn't tax your PC as much as the in-game action. Just because you get 75fps average in the benchmark doesn't mean the full game will maintain that level.





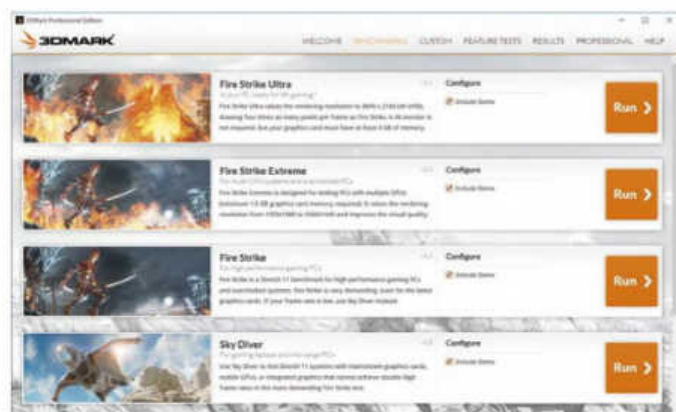
METRO LAST LIGHT

Also known as the ball-breaker, this is easily our most demanding benchmark. It's only with the latest high-end products from AMD and NVIDIA that we've started to see playable performance from this test. We don't even bother using this on low-end GPUs or laptops, as they'll just whimper and cry. One excellent feature of this benchmark is the ability to change all the options from the benchmark launcher, which resides outside of the game. You can also setup multiple different automated runs, so you don't need to manually restart it every time you change a detail setting. Very handy.

FUTUREMARK 3DMARK

But what if you want to run a benchmark that is free? Welcome to 3DMark, a synthetic benchmark that we love for its simplicity and accuracy. The makers of this have been incredibly careful to ensure it's not biased to any one GPU maker, and there are six different benchmarks included that each aim at a different level of hardware. Sky Diver is great for gaming laptops, while Fire Strike Ultra is aimed at SLI and CrossFire users.

The best thing about 3DMark is that it will automatically compare your system's result with similarly specced systems online. That way you can immediately see if there's a problem with your system; if your 3DMark score seems much lower than identically specced PCs, there's probably a nest of rats inside the CPU heatsink.



BENCHING FOR OVERCLOCKING AND SYSTEM FAULTS

Now that we've gotten the game tests out of the way, it's time to dig into the serious stuff. The following benchmarks are all designed to drill down into a very specific piece of hardware. They're not indicative of game performance at all, but they are handy for checking if an overclocked piece of hardware is going to remain stable, or if a component is failing.



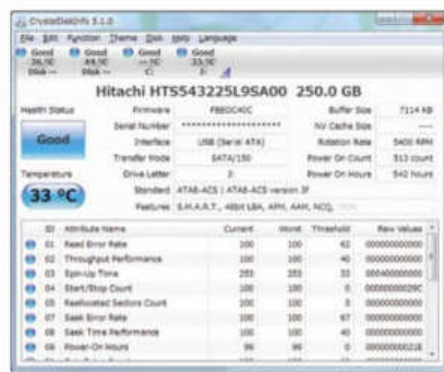
MEMORY TESTING

Solving memory issues can be one of the most frustrating, yet common, PC hardware issues. We use the popular freeware program MemTest to diagnose such issues – it's absolutely simple to run, and we've found it reliably finds bad sticks. As a backup, we also use the super serious GoldMemory test... but this has to be run off a bootable USB disk outside of Windows. Not so much fun.



CPU BURN-IN

You've just jacked up your CPU's frequency by 800MHz, and now you want to know if it will last longer than 37 minutes next time you game? Enter Prime95, the cruellest, meanest way to subject your chip to maximum load. This comes with an option called Torture Test, and you can ask it to load up the CPU, the memory or a combination of the two. We suggest changing the number of torture test threads to run to match the number of cores on your CPU, and then double it if you're packing Hyper-Threading.



HARD DRIVE FAULTS

Considering how magical hard drives are, storing gazillions of ones and zeroes in something the size of a small book, it's a miracle they don't fail more often. But when they do, we turn to CrystalDiskInfo and HD Tune to figure out if the issue is repairable.

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Gaming series

The new SAPPHIRE NITRO series is an evolution of our market-leading, award-winning, high-end graphics card technology – now made accessible for the PC gamer. Designed from the ground up, we've crammed in everything you need (and left out everything you don't) to maximize the gaming experience for your budget. The SAPPHIRE NITRO series boasts a range of features previously reserved for high-end cards, including long-life capacitors and award-winning Black Diamond Chokes, as well as our award-winning coolings solutions.

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Nitro Features



SAPPHIRE

OVERCLOCKING 101

BENNETT RING used to do this with a pencil

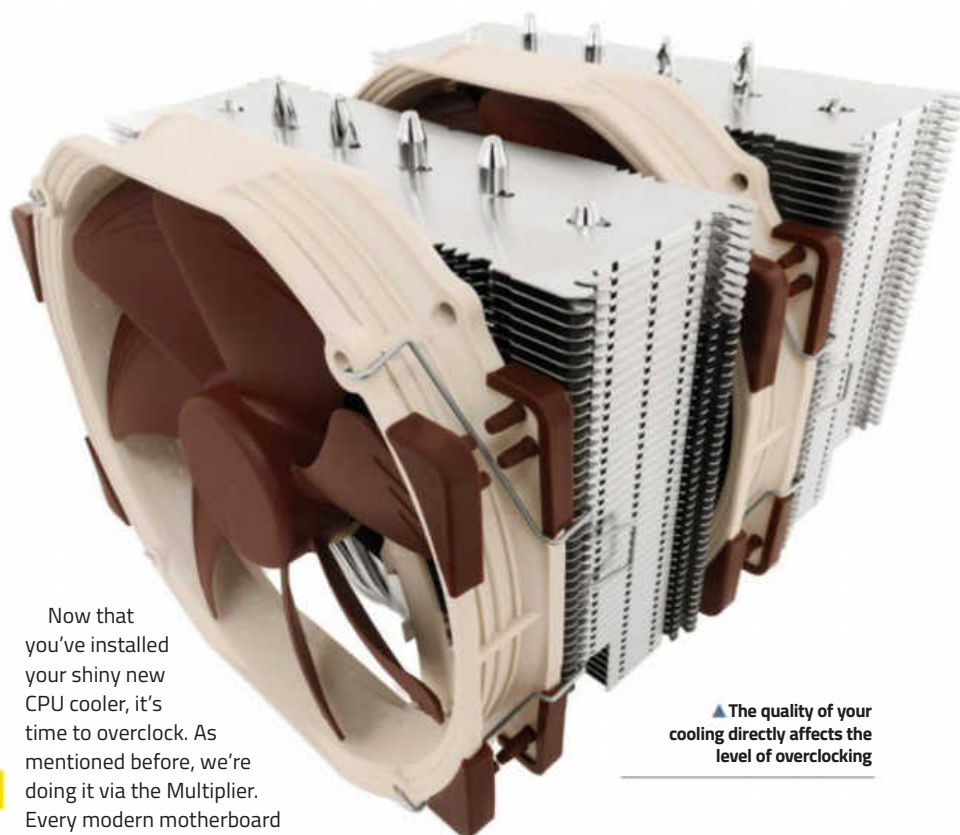
Overclocking your PC simply refers to taking a certain component and running it at a speed faster than it ships at. There are three major areas of the PC that can be overclocked; the CPU, GPU and system memory. In the best case scenario, it's possible to squeeze up to 40% better performance out of a given component. In the worst case scenario, you can actually damage the components you're trying to overclock, but we're going to show you how to minimise that risk. Having said that, before you embark on any of the following guides, you accept all responsibility for any damage to your system. We highly recommend backing up any and all important files on your PC before CPU overclocking, as it's possible to hose your hard drive if things go bad, though it's less likely these days. It's also worth pointing out that if you do damage your component via overclocking you've probably voided the warranty. Thankfully there's usually no way for the retailer to tell the difference between a CPU that was killed by overclocking or a CPU that simply failed.

CPU OVERCLOCKING – 500W

We're only going to cover the basics of CPU overclocking here without writing a 10-page guide with screenshots of every BIOS setting. We're also only going to cover relatively simple overclocking techniques, rather than the intricacies required to bring a CPU up to speed with Liquid Nitrogen. The good news is that overclocking your CPU is now incredibly simple, and can be done in a matter of minutes. And the method we're going to explain is called Multiplier overclocking.

To overclock your AMD or Intel CPU, you first need to have a chip that is Multiplier unlocked. For Intel users, just look for the K at the end of the product name. Meanwhile AMD users need to look for either an FX CPU, an APU with a K at the end of the product name. You're also going to need a motherboard that supports overclocking; the latest Intel boards to do so are the Z170 range. Thankfully AMD doesn't impose this limitation on their chipsets, so most AMD-compatible boards should support it.

Before you start overclocking your CPU, we *highly* recommend installing a better cooler on it than the one provided with your chip. A faster CPU is a hotter CPU, which is why there is a huge market for CPU coolers aimed at overclockers. Expect to pay \$70 for something decent.



▲ The quality of your cooling directly affects the level of overclocking

Now that you've installed your shiny new CPU cooler, it's time to overclock. As mentioned before, we're doing it via the Multiplier. Every modern motherboard that can overclock should have overclocking software available for it from the manufacturer's website. Grab this and install it now – AMD users can also use the official AMD Overdrive software. Fire it up and head to the CPU overclocking section. Before we crank the CPU to light-speed, we want to disable any features that automatically adjust the CPU's speed, as this can cause an unstable overclock. For both AMD and Intel users, look for a setting called "Enable Turbo Core" or "Intel Turbo Boost", and disable it. If your software shows any CPU power saving options, disable these as well.

Now you need to increase the CPU voltage, and this is the most dangerous part of the procedure. Jacking up the voltage too much will fry your chip, so we suggest a maximum voltage increase of around 10 to 15% over the

default voltage. Today's chips all come with varying voltages, so run a game while using a CPU monitoring app such as CPU-Z to see what voltage it normally runs at. Then head into your overclocking software and increase the CPU Voltage setting by 10%. In our screenshot our software refers to this as "CPU Voltage Offset" which refers to how much we want to increase the CPU voltage – in this case, 0.09V is safe. Now look for the Multiplier or CPU Ratio setting, and increase this by one. In our screenshot below, the default multiplier setting was x35, so we increased it to x36.

Then it's time to fire up a demanding benchmark to ensure the CPU doesn't crash. Once it's proven to be stable, leave the voltage as is, and increase the multiplier again, before running your benchmark again.

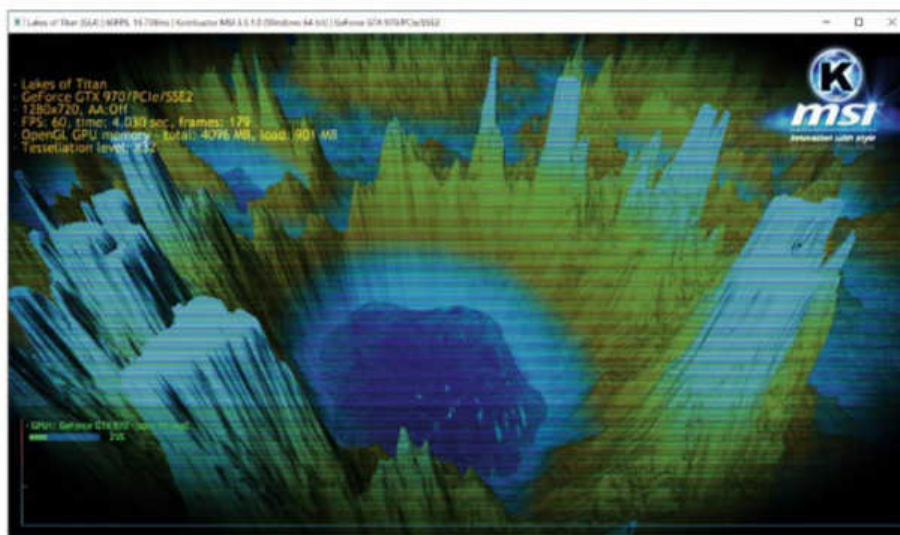
Eventually you'll find a level where the benchmark crashes – drop the multiplier back down to the last stable level and you're good to go. In this way we found it possible to overclock an i5-6600K from its default top speed of 3.9GHz up to a rock-solid stable 4.6GHz, a rather tasty 18% performance improvement for free. One word of advice, we recommend keeping an eye on your CPU temps during your overclocking, to ensure it doesn't exceed the maximum safe temp for your CPU. Each CPU has a different safe temp, so you'll need to find out what yours is. And remember to be very careful with the voltage!



GPU OVERCLOCKING – 500W

We recently managed to overclock a Gigabyte Gtx 980 Ti graphics card by a whopping 40%, and all it took was a few hours in front of a screen and benchmarks. Overclocking your GPU is even easier than the CPU, as there are far fewer settings that can impact it, although there are two separate areas for overclocking. The first is the GPU, and overclocking this is very similar to overclocking a CPU. Then there's the graphics cards' memory, which can also be overclocked.

We're going to use MSI's excellent Afterburner software for overclocking the graphics card, as it uses the exact same interface for both AMD and Nvidia products, making it super easy to explain. You can grab it for free from <http://gaming.msi.com/features/afterburner>. While you're there, also get the Kombuster GPU stress test application, which is also free. Install it, and you'll see this:



To adjust the Core Voltage, you'll first need to click on the Settings button, and then check the "Unlock voltage control" in the first screen. Hit OK, and then slide the Core Voltage all the way to the right; both AMD and NVIDIA have enforced strict voltage limits on their products, so it's incredibly unlikely that you'll fry the GPU. Now increase the power limit slider all the way to the right as well.

Once that's done, it's time to increase the GPU speed by 25MHz. Head to the Core Clock (MHz) slider and increase it by 25MHz. Hit Apply, and then fire up the Kombuster stress test (above).

Let this run for a good 15 minutes or so, checking for any visual artefacts. If there are

none, exit the program, and increase the Core Clock setting by another 25MHz, then run the stress test again. Keep repeating this procedure until you find the ceiling for your GPU. If the benchmark crashes or any artefacts appear on screen, back the Core Clock slider down to the last safe level.

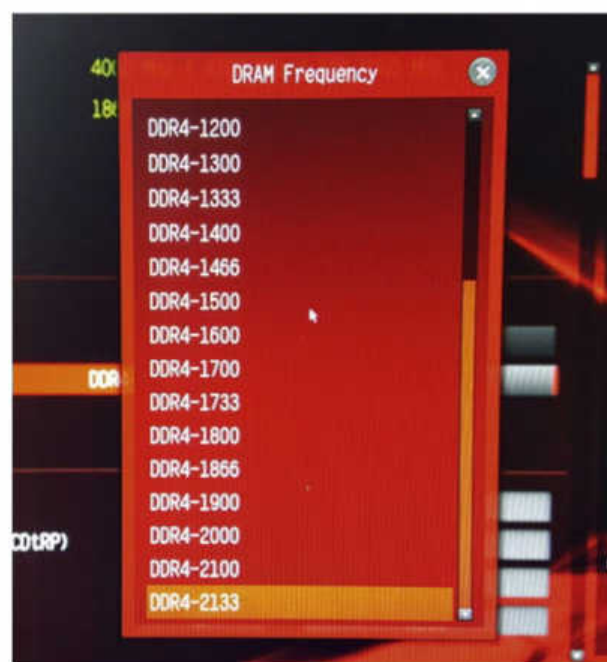
Overclocking the memory is exactly the same, but we adjust the Memory Clock (MHz) slider instead. Keep increasing in 25MHz increments, running the Kombuster stress test between each adjustment, until you find the maximum safe level for your memory. Note that memory doesn't tend to overclock as well as the GPU – a 10% memory overclock is pretty good, while a 30% GPU overclock is possible.

MEMORY OVERCLOCKING

And now we come to the most mystical area of overclocking, the system memory. We're going to focus on DDR4, because that's both the most recent format of memory to hit the mainstream, and is also capable of some truly outrageous speeds. Intel's new Skylake platform has an officially supported speed of 2133MHz, but with the right memory and motherboard (aka the expensive stuff), we've seen benchmarks of folks running their DDR4 at almost twice the speed, 4000MHz. Due to DDR4's latency issues (the memory timings of DDR4 vs DDR3 are much looser), increasing the speed of your DDR4 memory is actually a rather significant way of improving performance... in extremely specific

scenarios. These scenarios include synthetic benchmarks, copying massive photoshop files into memory, and a few scientific benefits. From the myriad of benchmark results we've read, increasing DDR4 memory performance will have little or absolutely no impact on game performance. Still, we'll show you how.

It's as easy as heading into your BIOS as your PC boots up (hit Delete, F1 or F6 to enter the BIOS, depending on your mobo. Now find the OC or memory section, and you should see a field that says DRAM Frequency. Simply increase this to the next highest setting, save changes and reboot. Run a thorough stress test, and if it passes, head back into the BIOS and rinse and repeat. **PC**



MANUFACTURING SPOTLIGHT

► THERMALTAKE



It's not a toaster*

*But it will read any SATA drive via the world's fastest USB port



VOLANS DS31

Aluminium USB 3.1 Gen 2 (10Gbps) HDD
Docking Station with RAID

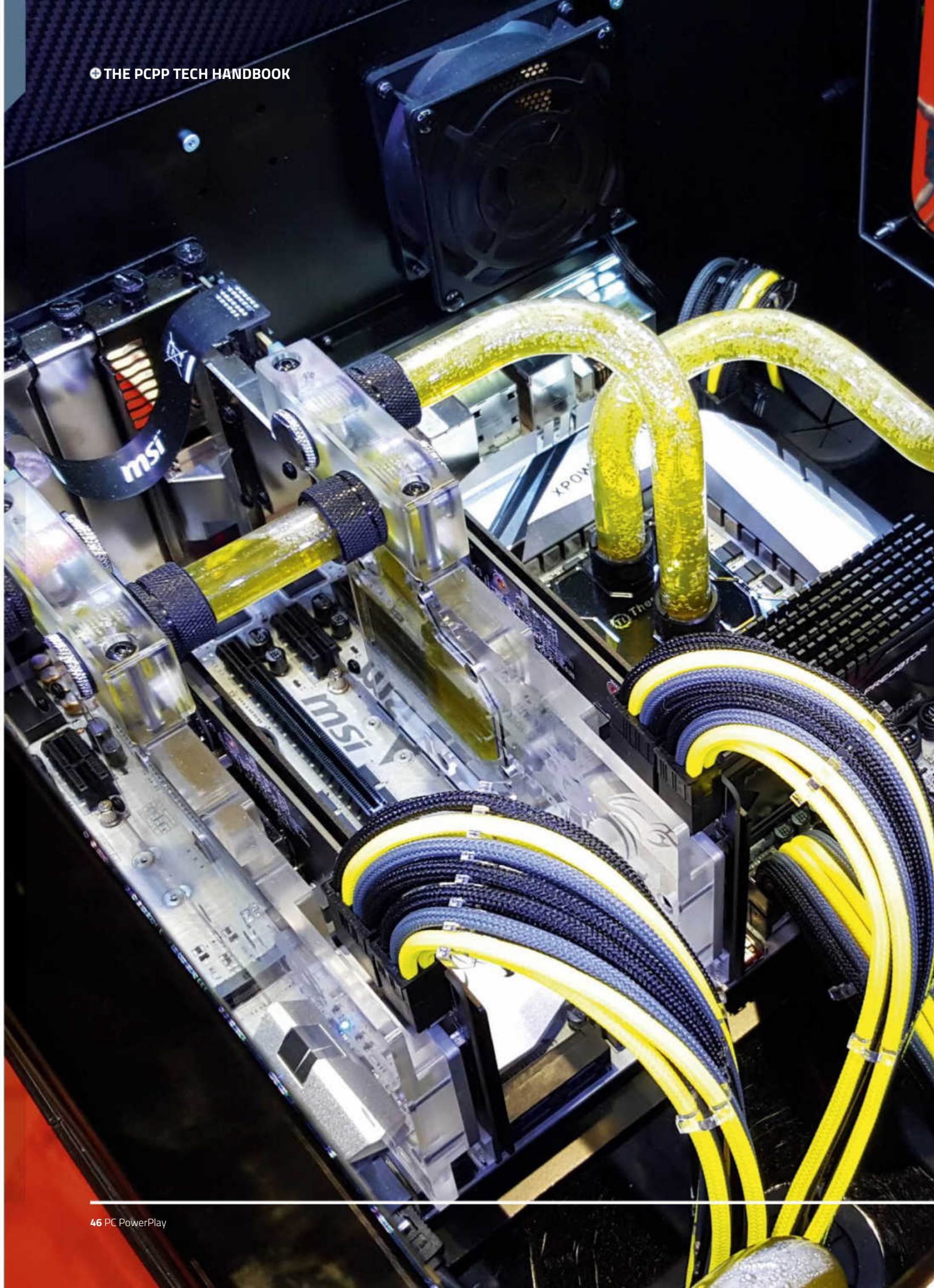
AVAILABLE FROM:

Capitol Computer (NSW)
www.capitolcomputer.com.au

Centre Com Superstore (VIC)
www.centrecom.com.au

Computer Alliance (QLD)
www.computeralliance.com.au

PLE Computers (WA)
www.ple.com.au



PC COOLING GUIDE

DAVID HOLLINGWORTH examines the best gear, the right habits, for keeping your machine cool and running smooth.

Once upon a time cooling was one of the most essential parts of any PC build. Even at stock, enthusiast and gaming hardware tended to push a lot of heat, and if you overclocked your CPU, then you were really asking for it.

I have fond memories of a friend's high-end gaming system with its side panel off, a desk

fan perpetually blowing air into the oven-like interior.

These days a lot of PC components are much more heat tolerant, able to handle heat better as well as put out less of it. Nonetheless, good cooling is still important, and overclocking or running an SLI setup can still create a good amount of waste heat. It's also important to take into account not only the PC hardware's own heat output, but also the location of your PC, and in the Australian summer, a bit of extra cooling can not only help PC performance, but it can help you be more comfortable, too; the last thing you want for a long day of gaming is to have to put up with a huge thermal load sitting right next to you.

THE RIGHT COOLING FOR YOU

Intel has recently stopped selling their CPUs with a cooling fan, so while it used to be possible to get your system up and running with nothing but the stock cooling on your case and that skimpy little Intel cooler. It may not have been wise, but you could do it.

Now though, you're forced to consider the

■ A lot of all-in-one kits don't tend to be much better at cooling than a heatsink and fan set-up ■



▲ Cooler Master Nepton 240M all-in-one water cooling kit

right cooling for the job, which is probably an improvement. On top of that, your choice of cooling is now wider than ever, thanks to the ubiquity of all-in-one water-cooling kits. Again, water-cooling used to be rather complex – you'd need to mix and much tubing, mounts, radiators, pumps, all kinds of esoterica, and then work those cooling loops into your PC case, which may not necessarily have been built with water-cooling mind.

That said, water-cooling kits are not a silver bullet. A lot of all-in-one kits don't tend to be much better at cooling than a heatsink and fan set-up – some are actually less efficient. What they are, however, is much quieter under

normal operation. Where an air-cooled system relies upon the mechanical action of a fan or fans to push air over a set of cooling fins, the radiators in all-in-one kits are much better at radiating heat, and the liquid itself, too, is a more efficient cooling mechanism. Under heavy load, these set-ups can be just as noisy – or even noisier. The smaller fans on these units need to spin faster to push the same amount of air as larger fans, and you've got pump-noise to keep in mind, too.

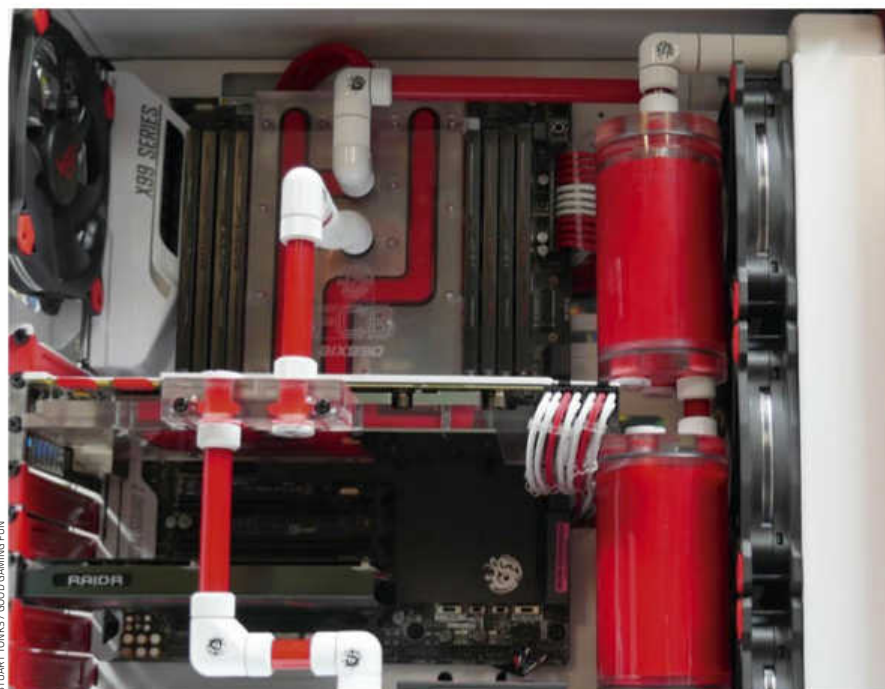
Now, that said, if you're system is under load, it's very likely because you're gaming, and you'll either having a lot of sound coming out of your PC, or be wearing headphones. And while you're just browsing or performing other low impact tasks, your PC will be that much quieter. On top of that, water cooling setups also tend to equate to more room in your PC, too. If you're an inveterate tinkerer, not having to deal with a massive PC heatsink is a real plus.

And if you're worried about leaking... don't be. Modern all-in-one kits are super-reliable. We've not heard of any disasters in the last couple of years, and all-in-one models from Corsair and CoolerMaster come with impressive warranties to boot, even if you are worried about the extra mechanical strain.

IN THE AIR TONIGHT

Water-cooling is, well, cool and all, but a lot of people still like the solid reliability of a big old lump of copper and aluminium. And there's actually still some advantage to be had by sticking with a pure air-cooled rig.

Take Noctua's massive NH-D15, which boasts two 140mm fans blowing air over two



◀ Custom watercooling with red liquid

stacks of aluminium cooling fins, connected to copper cooling pipes, in turn looped through a solid copper base. Sure, it's pretty much an entire Coca Cola canning factory in your PC case, but it remains one of the most efficient coolers on the market, and is very quiet, thanks to the larger fans and the impressive array of fins.

The other advantage of big cooling towers like this one is that they managed to push air over hot-running motherboard components, too – something which closed-loop systems don't manage. This kind of cooling also fits in with the fans that are likely already installing in your PC case, so that you have a continuous line of exhaust; cool is pulled into the front of the case by fans on the front panel, pushed into the CPU cooler where it warms up as it pulls heat out of your CPU, and then is blown straight into your case's exhaust fan.

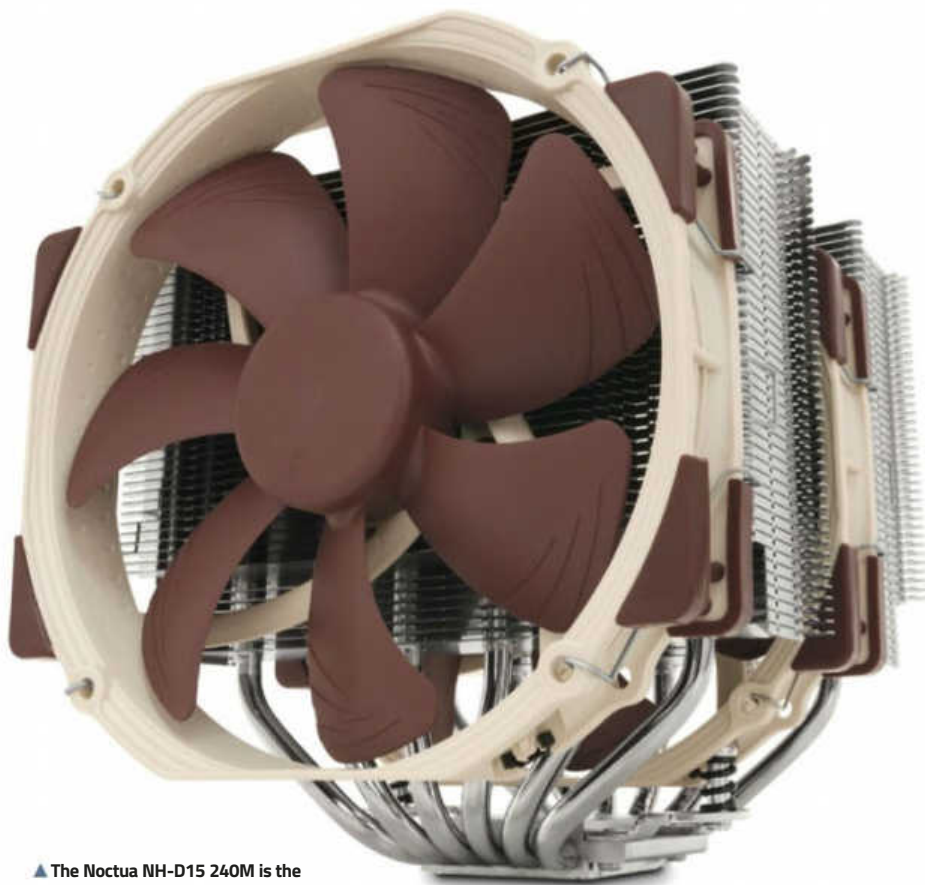
And, finally, air-coolers are generally much cheaper, though there are some very economic water-cooling kits on the market.

That said, there are some drawbacks. You lose a lot of space, for one, which can actually impact ambient heat build-up from other components, and they are quite heavy. Modern motherboards are pretty well reinforced for just this reason, but it's still something to consider – especially if you move your PC around a lot.

They're also a right bastard to keep clean. Even with a well-filtered case, micro-grit and dirt will still find its way into your case, and the natural airflow will see it deposited on the fins of your heatsink. If you don't regularly stay on top of this, you'll actually see cooling efficiency drop off, as the dust acts as an insulator, while also keeping cool air away from the aluminium surface.



▲ Cooling towers can be doubly efficient as they also blow air over the mobo



▲ The Noctua NH-D15 240M is the size of god but extremely efficient

THE REST OF YOUR CASE

Your CPU may be one of the hottest parts of your PC, but that's no reason to ignore the cooling requirements of other parts. Your video card, for instance, may come with a fan and cooling attached, as does your PSU, but you can help both out by keeping a few things in mind.

First up, when you hear system builders talk about cable management, it's not just because it makes for a neat and easy to access build. If you've got cables just blobbed into a mess in the middle of your case, that's going to act as a block to airflow, not only gather more evil dust, but helping build up more heat in your case, which will in turn impact other parts. Similarly, if your case is unfiltered, that means dust build-up on every moving part. And that means more heat.

Basically, if you have pets, or live near a busy road (or even under a flight-path), you can expect more grit than normal, so you'll really do yourself a favour if you invest in a well-filtered case. Go for filters that are removable for cleaning, and keep an eye on any grills covering your fans, as these too can get awfully clogged up.

Make sure your PC also has good ground clearance. If you're up on a desk, you should be fine, but if your PC is resting on carpet, its feet are likely to sink into the pile, bringing any intakes at the bottom of the case almost in contact with a large amount of fluff and grit. Also be aware of where your PC's exhausts and

intakes are, so that none are blocked by walls or other obstacles.

It's also worth taking note of where your fans are placed out of the box in your case. If there's a single intake fan in the front panel, it's likely either towards the top or bottom of the case. Both are useful, for different reasons. A higher fan helps direct air directly into any CPU cooler, while a lower fan pushes air over possibly hot hard drives; so if you're pushing your system, and likely to be thrashing your storage, investing in a second intake fan (or buying a case with two or more intakes at stock) could be wise.

In fact, we'd always recommend having more intake fans than exhaust fans, because that means you can maintain positive air-pressure in the case. With positive air pressure, more air is being sucked in than the case can exhaust; this means that dust is less likely to settle into the case through any other access points, like upper mesh panels or other vents.

Now even if you do follow all this advice, do make sure you keep an eye on your PC internals. No matter what you do, or how sealed your case is, it will get dust and grit inside, so open it up every few months. Invest in a can of compressed air, and blast that gunk out of your case. Clean the blades of all your fans, make sure everything's pristine.

And the not insignificant investment that is your PC will go on rewarding you with years of pleasant fragging. **PC**

PC DISPLAY JARGON

CHRIS PIRINA has a new resolution

UHD/4K

Film and Television use different standards for 4K resolution. Television utilises 3840 x 2160 which gives a 16:9 aspect ratio, called Ultra High Definition (UHD). Film standards for 4k uses the slightly higher resolution 4K 4096 x 2160 with 1.9:1 ratio which is much closer to a true rectangle.

5K

A resolution of 5120x2880 giving a 16:9 ratio, the standard ration for TVs and computer monitors.

8K

A resolution of 7680x4320 or higher. At 16x the resolution of 1080p, 8k is seen as the next step on ultra-large televisions, like the 98" 8K LG TV shown off at CES 2015, due to the fact that the resolution is high enough that individual pixels are indistinguishable to the human eye even at large scale. 8K Fullframe (8192x8192) is the most common resolution used in full dome projection, as is seen in planetariums or surround projection amusement rides.

REFRESH RATE

Amount of times a screen will refresh an image and is measured in Hz, a higher refresh rate creates a smoother video with less motion blur.

PROGRESSIVE

Every frame of the image is sent in its entirety giving a higher quality video

INTERLACED

Frames are sent with alternating scan lines (rows of pixels). This reduces image quality, and creates flicker, most noticeable when filming a screen

SD

Standard definition, 704x576 pixel wide image in 4:3 aspect ratio for PAL broadcasts.

HD

High definition, 720x576, bumping standard definition to a 16:9 aspect ration compliant with modern devices.

FULL HD

Full high definition, 1080x1920 image, 16:9 aspect ratio, the current standard for PAL Broadcast



▲ The LG 4K OLED was at the top of most PCPP writer's Christmas wish lists

QHD

Quad high definition 2560x1440, four times the resolution of high definition. 16:9 aspect ration

qHD

Quarter high definition, 960x540, a quarter of high definition while retaining a 16:9 aspect ratio, made for smaller screens like mobiles to make displays less demanding of battery.

CRT

Cathode ray tube, or tube TV, emits curved light from cathodes, which are projected onto a thick screen, often curved itself to retain proper shape. Used in rear projector TVs

LCD

Liquid crystal display, a basic by modern standard display that uses liquid crystals and light to display images, used in less image intensive devices usually such as digital clocks. LCD is displayed mostly on a flat panel.

LED

Light emitting diode, or more accurately, LED-backlit LCD, which replaces a basic LCD backlight, which is cold cathode, and replaces it with smaller independent and more efficient light diodes. Allows for better black levels and thinner devices.

OLED

Organic light emitting diode, a type of LED which is a type of LCD. OLED shrinks the scale further, using individual pixel lighting. This hampers light output, because the diodes aren't as powerful, and can cause dead pixels on your screen, but they also allow for richer blacks and greater light and colour variation

PAR

Pixel Aspect Ratio, the size relationship between a screens height and width, read as height:width. For example, most cameras shoot at 16:9 which is what most displays are set to. Old computers and vertical phone screens are 4:3.

▼ Curved 21:9 screens are great for gaming but kind of useless for TVs





PHANTOM-S

GAMEPAD EMULATOR

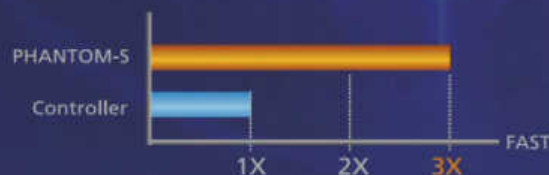
Can't Aim and Shoot Fast Enough or Accurately When Playing FPS Games on PS4, PS3, XBOX 360 or XBOX One?



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The PHANTOM-S™ allows you to easily become a top FPS player with customized keyboard and mouse controls like you've never experienced. Whether you're a professional PC or console game player, the PHANTOM-S gives you the advantage.



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Rapid fire

Regular Software Updates



Provides New Features and
Boosts Performance

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HERTZ SO GOOD

ASHLEY MCKINNON optimises your network

As our lives become more and more reliant on the internet and access to data – so does our expectations to have that data immediately. Streaming media from providers such as iTunes and Netflix has only increased our demand for fast connections. Recent years

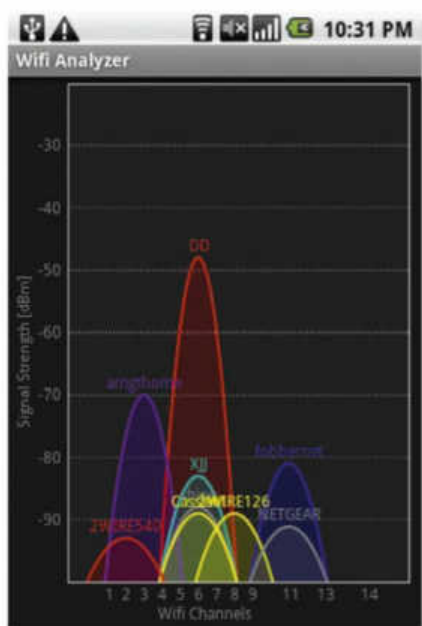
has seen internet speeds increasing rapidly and we've almost hit (some countries have) the point at which your internet connection is just as fast as your home network. This is all good news for the multiplayer gamer as well as the experiences have become larger, more

intense and more immersive. Just about every home now has its own network (in one form or another) and most people are looking into how to make it better.

Setting up a home network these days is a rather simple task. Plug and play (PNP) devices and intuitive graphical user interfaces (GUI) mean even the average person can buy some network technology off the shelf and stand a good chance of plugging it in and making it work. While it is true that most network technology does work straight out of the box, getting the most out of it takes some more effort. Here we will run through some ideas to make your home network faster, more reliable and efficient.

First off – check your drivers. It may sound simple but computer equipment manufacturers are constantly refining and upgrading their drivers to get as much performance as they can out of them. Not only should you check the manufacturers' website for updates but also check the chipset makers' website. Most notebook and motherboard manufacturers use a common set of networking equipment so check their website as well for updates. Common chipset makers include Intel, Realtek, Broadcom and Marvell.

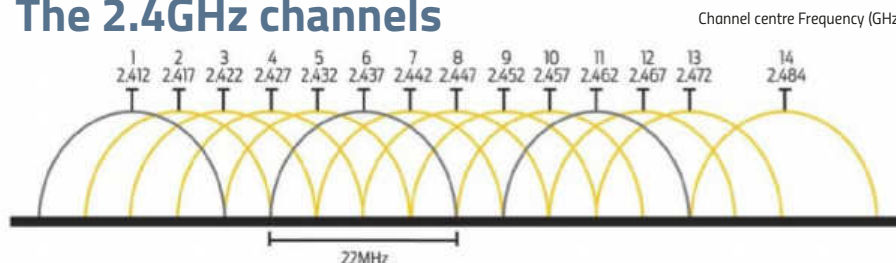
Along the same lines – check for updates to your routers firmware. Most people never think to check this but updated firmware can easily make you router perform better by ironing out any problems found since its release. Make sure you take a backup of your routers firmware before upgrading however because not all upgrades go smoothly. Next



▲ Wifi Analyzer measures your router's signal strength from various locations to optimise placement



The 2.4GHz channels



we move onto where you physically locate your router.

Often when people buy a Router and set it up they locate it where it's convenient, and this can be say next to a printer or monitor – or behind a PC. This convenience however doesn't help with the Routers Wifi signals being sent out. Every time a Wifi signal is bounced off a wall, door, piece of furniture or anything else blocking its path it loses strength as some of that signal is absorbed. That's the reason why most large antennas are located on top of buildings or out in the open rather than down at street level. You want as little as possible near your Wifi router to ensure the signals are going out unobstructed. Try moving your Router around and check your Wifi signals – use an app such as Wifi Analyzer to measure your Wifi routers signal strength from various locations and see how moving its location makes a difference. Wifi Analyzer is also a great tool for determining blackspots in your home where Wifi coverage drops. In an ideal world you would place your Wifi Router in the centre of your home so as to get as much coverage to devices as possible – but in reality this normally isn't an option.

Wireless networks generally run at 2 different frequencies – either 2.4Ghz or 5Ghz, or a combination of both. 2.4Ghz is the older standard, but offers better penetration (signal carry through walls, doors, ceilings, etc.) The newer standard 5Ghz offers higher speeds and far less interference from other devices. These frequencies are then further broken down into channels. 13 channels are available on 2.4GHz – with 19 available on 5Ghz. Channels themselves interfere with each other – so

▲ A pictorial representation of channel overlap

you may actually be experiencing interference from someone else's Wifi network. With 2.4Ghz, the frequency is 100Mhz wide, with each channel taking up 20Mhz – so going by the numbers 13 channels x20Mhz doesn't fit into 100Mhz so this is why there is channel overlap. Each channel can get interference from the two before and the two after (for example channel 4 could get interference from channels 2,3,5 and 6). A lot of Wifi routers are set to automatically assign a channel but you can set this manually as well. You could try this yourself and test the signal strength on various channels (channels 1, 6 and 11 are good choices as they are non-overlap channels and usually provide the best option).

You don't have to worry so much with a 5Ghz Wifi network as there is no channel overlap. Add to this the fact that 5Ghz has a better range than 2.4Ghz. Bottom line here is if you have the option of using 5Ghz then use it. A lot of routers that use both the 2.4Ghz and 5Ghz bands allow you to setup Wifi networks for each band. This can be a good idea as if you setup a single Wifi network you use both

Wireless networks generally run at 2 different frequencies – either 2.4Ghz or 5Ghz, or a combination of both

bands some devices may start automatically switching between the two – giving you an impaired connection.

Another option to increase your Wifi coverage and speed is to extend your network. This can be done by utilising devices such as a Wifi Extender or an Access Point.

A Wifi Extender (also sometimes referred to as a repeater) does as its name suggests – extends your Wifi network. They are devices that plug into a power socket, accepts a Wifi signal from your Wifi Router and retransmits (repeats) it at an amplified strength. The main drawback with a Wifi Extender is its placement. It has to be close enough to your Wifi router to receive a decent signal from it as it can only provide as much Wifi speed as it can accept from the Wifi Router. Position it too far away and you will suffer from retransmitting a low and slow signal.

An Access Point (AP) is used to enhance your network by adding another Wifi network. An access point acts as a bridge between your wired network and you wireless devices. You can place an AP anywhere you like – as long as there is wired network connectivity available for it. The difference between an AP and a Wifi Extender is that an AP isn't just extending a wireless signal – it is providing a new wireless network attached to your wired network.

If you don't have cables for your wired network criss-crossing your home then don't worry as there is a solution. Power-Line Networking (PLN) devices allow you to make use of your homes existing power cabling to act as a network medium. You plug these PLN devices into a power socket and it creates a network bridge between the two. You would then typically attach via Ethernet cable one of these PLN devices to your router, while the other one you could attach via Ethernet cable to whatever else needs network access – say a TV, media player or PC / Notebook. You could also attach an aforementioned AP and setup a separate (strong signalled) Wifi network. Speed of these devices can vary quite dramatically however as they do come in different speed ratings (500MB/s is currently the fastest available here in Australia). The quality of your homes power infrastructure can affect the PLN devices as well – bad cabling means slow speeds.

Speaking of bad cabling – never buy cheap cables. Every time I go into the local computer store I see cheap Ethernet cables for sale – don't be tempted to buy them. Get quality Ethernet cables – and go for the fastest rated cables you can find – currently Cat 6E. These Ethernet cables are rated to a speed of 1GB/s and I know a lot of your devices may not be capable of that speed but there's nothing wrong with overkill when it comes to

networking. Cat 6A – capable of 10GB/s is starting to appear but isn't popular yet. I find it funny when people say they aren't getting the speed they were hoping for from their brand new 300MB/s Wifi router and then you find out they have used a Cat5 (100MB/s) Ethernet cable to connect between the router and their network. A network is only as fast as its slowest component. Also, if you have any switches on your network check their speed – no use having a 100MB/s switch plugged into a 1GB/s network. And don't just assume the cables that come with your equipment are good quality – usually they aren't.

Another way to squeeze more speed out of your network is aggregation. If you have a higher end PC chances are it has more than one Ethernet port. You can combine two Ethernet ports into a single virtual Ethernet port. This is called Link Aggregation (or NIC Teaming). You now run two network cables to your router offering better throughput.



▲ A Range Extender plugs into a powerpoint and retransmits and boosts a Wifi signal

Check your router specification however before trying to set this up as not all routers support this.

We've touched on several areas here and given you some ideas to check on your own network to see if improvements can be made. Just remember to take your time and test, test and test again. **PC**

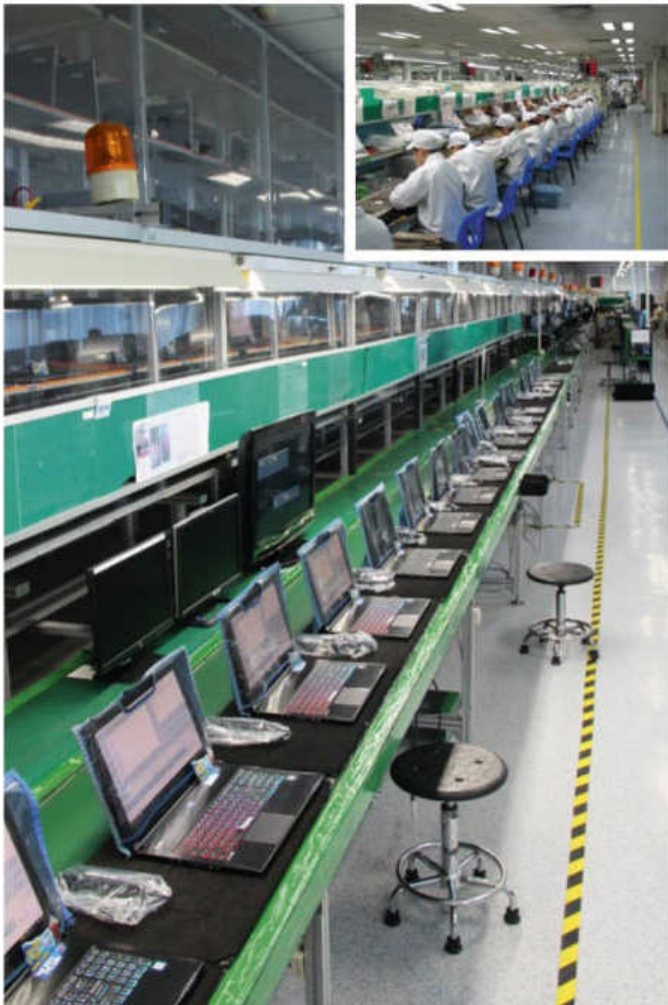
► Like many Wifi routers, the ASRock Gaming G10 features 5Ghz and 2.4Ghz bands



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IT'S SSD TIME

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It's time to get an SSD. Actually, we can't believe you haven't got an SSD already. Trust us, once you pop one in your computer, you'll be kicking yourself for not getting one earlier.

What's so good about SSDs? The hard drive is the slowest part of the computing chain. When you do something on your computer, it goes from RAM, which is super fast, like nanoseconds fast, into the CPU's cache, which is even faster still. Then it has to wait for your crappy spinning disk, which takes milliseconds, to get things done. 1 millisecond is 1000th of a second. A nanosecond is a billionth of a second – a huge difference. Imagine being a computer waiting the crappy hard drive to catch up.

A fast 7200RPM, traditional spinning hard drive has an average 4K block size write latency of around 5ms. A basic SATA SSD is around 0.04ms. A vast difference. Even though we are measuring fractions of a second, that fraction of a second makes a discernible difference as to how your computer reacts when doing all things it does with storage – caching, loading, saving, indexing. Making that happen a hundred times faster is why an SSD is so damn good.

The other reason SSDs are great are their pure bandwidth advantage. Because the SSD can read and write data faster than a traditional HDD, long file copy or read operations complete in a fraction of the time. Take for example a modern 6TB 7200RPM HDD, it can sequentially write data at about 200MB a second. A cheap 480GB SSD will achieve around 450MB a second. More than double. This sort of performance is less discernible day to day than latency, but still makes a difference when copying data around or an app or the OS deciding to read or write a bunch of data, preventing you from doing much else until it's done.

THE NVME PROTOCOL

If you're convinced that an SSD is for you, you'll love the fact that there's even faster SSDs just released onto the market. SSDs are so fast, that the normal SATA connection used to connect a disk to your computer is too slow. It just doesn't have enough bandwidth. It's compounded by the now ancient AHCI protocol that your PC uses to structure and deliver the data. AHCI was designed for hard drives, it replaced the even more ancient IDE protocol and with the advent of SSDs a whole new approach was needed. AHCI's design didn't take into account the ultra low latency a modern

▲ Samsung NVMe M.2 SSDs


▶ The Intel 750 is a staggeringly fast (and expensive) PCIe SSD

SSD is capable of. To combat this, the industry has settled on a new protocol for compatible data drives, called NVMe.

NVMe (Non-Volatile Memory Express) is an all-new standard designed from the ground up for SSDs and talks to the rest of the computer of over the PCIe bus. On a traditional hard drive you will still set your BIOS to use the AHCI standard, but using the NVMe standard for SSDs results in better latency and using PCIe instead of SATA opens up gigabytes per second of bandwidth SATA just doesn't have.

COMPATIBILITY

Only recently have SSDs been announced which support the NVMe standard. The only mainstream SSDs to do so are the Samsung 950 Pro and Intel 750. NVMe support also requires use of the latest Z100 series chipsets from Intel, so a CPU and motherboard upgrade is required if you want to take advantage of the fastest SSDs around. How fast are they? Well the 512GB Samsung 950 Pro can read data at over 2200MB/second and write data at over 1000MB a second. Latency wise, it can write data in 4K blocks with only 0.021ms of latency, twice as fast as a SATA based SSD and orders of magnitude faster than the practically vintage magnetic spinning disks.

There is no doubt that buying the fastest disk drive you can afford will make the most noticeable impact on your computer's day to day performance. By speeding up the slowest part of the computer, everything else gets a chance to perform at its best, so on your next PC build, spend a little extra and get yourself the best SSD available – you'll appreciate it more than the faster CPU. 

+ ARE HARD DRIVES DEAD?

Not at all, in fact the plummeting price of mechanical drives opens up new flexibility with your build planning and budget. We suggest that you include a very high capacity 3.5-inch hard drive, and supplement it with SSDs. A 4TB drive can be had for around \$200. We suggest that going beyond that capacity means it's time to look at running a NAS (Network Attached Storage), if you're not already. Simply adding capacity to your PC internally will use up your available PCIe lanes – especially if you want to run a newer NVMe SSD, which can consume up to four lanes for a single drive.

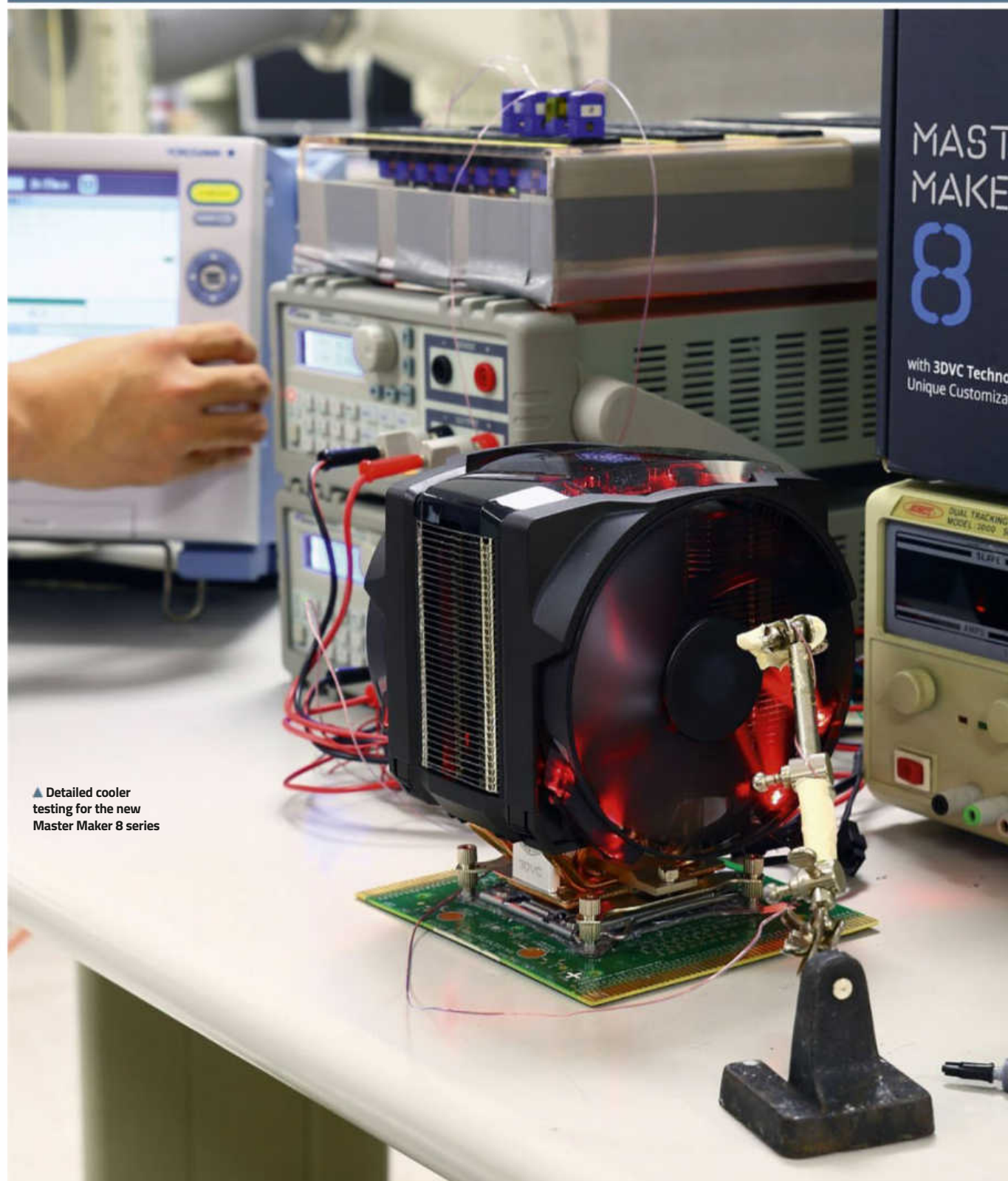
NAS enclosures are mini PCs, complete with CPU, RAM and an operating system of sorts. There are many good choices for a consumer NAS, and at this point we generally recommend Synology largely because the software is leaps and bounds ahead of the competition. If your budget can stretch, go for a 4-bay NAS. That was you can add drives over time. A 2-bay NAS might be a good deal cheaper, but of course is limiting your expansion options.

Loading up a NAS with hard drives and chucking all your media on it also means you can more simply stream music and video through the house, as your PC no longer needs to be up and running to access those files. Many NAS products can now transcode 4k video in real time, like the Synology 216play.



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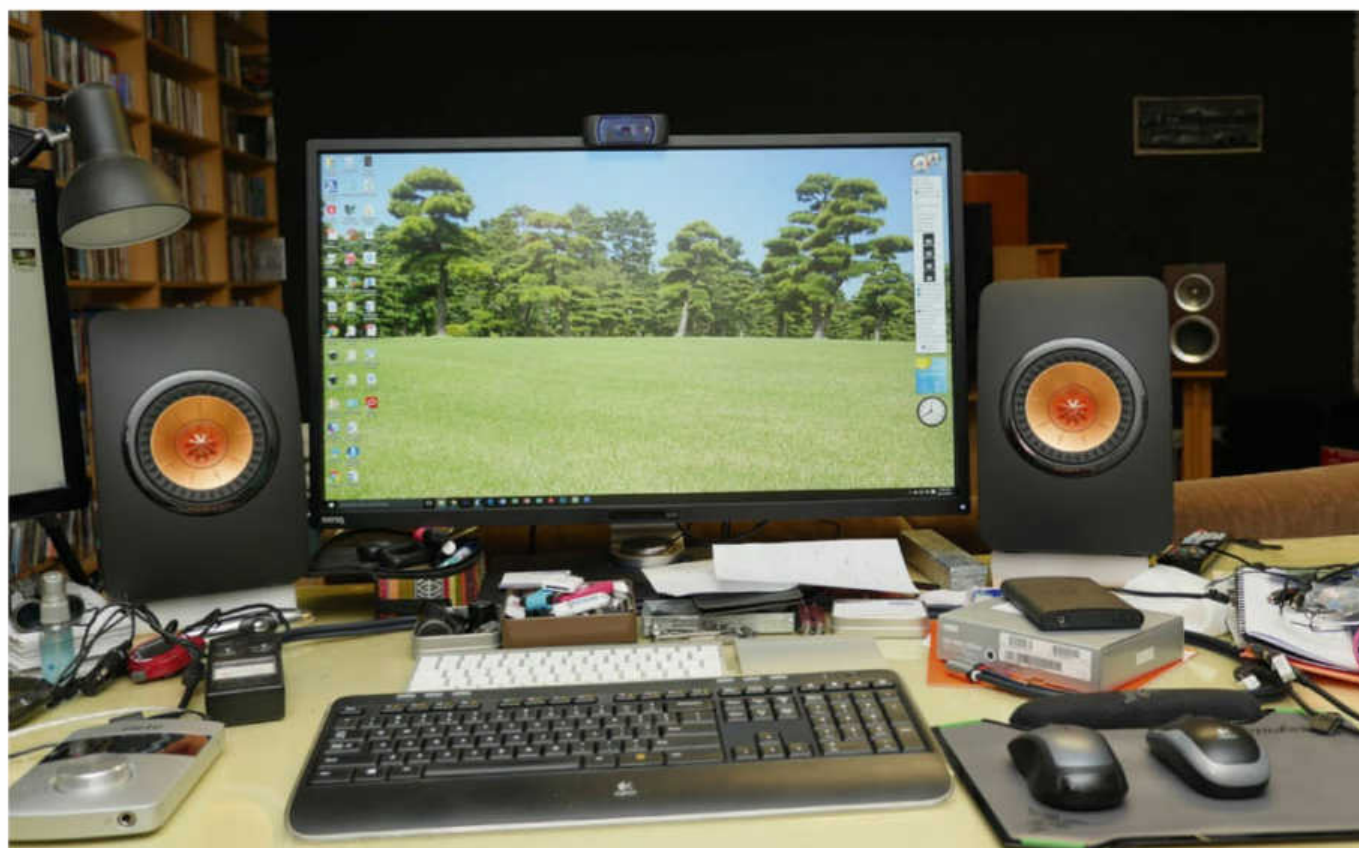


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LISTENING TO GAMES

STEPHEN DAWSON whispers sweet nothings into your ears



George Lucas is said to have said that 'Sound is 50 percent of the moviegoing experience.' Which is actually a very silly statement. You can't divide an experience between two of its contributing factors. Absent sound or absent vision, you're probably getting just five per cent of the combined experience.

Nonetheless, it captures some essence of not only movie-going, but game playing. Shooting the enemy is enormously more satisfying when there's a visceral thunk from the sound of your 5.56mm rifle than a mere sketch of what's happening from some plastic computer speakers. Your game score can even be higher if you can accurately and instantly detect the direction of hostiles from their sound.

Likewise for ambience. Where mood is part of the gaming experience, much is delivered almost unconsciously through a sound field that may be as much behind the player as in front, and often includes a deep bass throbbing that will be inaudible to the player with inadequate speakers.

To get that – or as much of it as you can afford to spend – means making decisions. And that in turn depends upon how you do your gaming. Fundamentally, the choices come down to Desktop vs Lounge room, Stereo vs Surround, and the specific type of speaker that you want.

THE DESKTOP VS THE LOUNGE ROOM

At a desktop is where most gamers will be, most of the time. But some will want to take advantage of a large screen home theatre system, maybe even with a front projector.

There are pros and cons to each. Serious action play favours desktop because gaming monitors are faster than TVs. Add a thirty millisecond lag before you see the bad guy emerge and you're doubling your reaction time.*

But both need addressing, because the requirements are very different.

(* TVs and home theatre projectors typically delay the image by 80 to 200ms in normal mode, and even in game mode, if available, 40 to 50ms.)

SIZE

The first difference is size. Not physical size – although that can come into it – but the size of the sound. A lounge room sound system must have the power and authority to fill a large space with sound. Fill it, not just deliver the sound directly from the speakers to your ears.

Your desktop system does not need to fill any space. The front speakers are just eight or nine hundred millimetres away from your ears. Most

of the sound you will hear comes directly from them, not from reflections (more about that shortly). Sound intensity, like many physical phenomena, is subject to an inverse square law: if you double the distance away from the sound source, the intensity falls away to one quarter strength. You're sitting close to your speakers so you need less volume from them, which means your system needs less power.

That in turn makes for smaller 'main' speakers. Which is why there are so many compact computer stereo systems available. Many of these can do a respectable job, so long as they front left and right speakers are accompanied by a subwoofer. A small computer speaker – regardless of talk of woofers and passive radiators and such – can't produce a decent level of deep bass. But a small computer speaker – well designed, with good components – can produce midrange and high frequencies for an enjoyable performance.

A cautionary word on power. Don't worry too much about how much power the system is said to produce. Even if the figures are honest, the power output of an amplifier is only part of the story when it comes to how loud a speaker system can go. An equally important part of the story is how efficient the speakers are.

In hifi, that's a specification often quoted – as a 'sensitivity' measure. But most computer speakers have the amps built in, so this

figure isn't quoted. Even 'SPL' or output level measures aren't of much use because there aren't really many standards for consistent measurement. You're going to have to go by ear, literally, for this kind of thing.

NEAR FIELD VS AMBIENCE

A loudspeaker does not 'beam' its sound from its cones to your ears. It emits the sound in all directions. Or more precisely, at high frequencies the sound comes out in kind of the shape of a cone, and at lower frequencies it spreads out more evenly. The higher the frequency, the tighter the cone. Yet even at very high frequencies, a significant proportion of the sound is going off to the sides, and upwards and downwards.

So what?

If you are sitting close to a speaker, you are getting most of what you're hearing directly from the speaker. This is called 'Near Field'. It can be quite close to headphones in terms of precision, but without the annoying sense that the sounds are located in the middle of your brain (I know, I know, 'surround' headphones. We'll get to them.) To get the best out of Near Field speakers, they ought to be aimed very particularly (see Box 'Point your speakers'). If possible, have them sitting a little forward of the monitor to reduce acoustic reflections from its surface.

But things are different in your lounge room. Because you are relatively distant from the speakers a much greater proportion of the sound that you hear is not coming directly from them, but after reflections from the walls, ceiling, floor and furniture. The room itself and how it is finished is making a substantial contribution to the sound. That can soften the impact, slightly reduce vocal coherence and add a slight delay. Sound takes around three milliseconds to travel one metre. Speakers at three metres can add nearly thirty per cent to your reaction time when audio is the cue.

STEREO VS SURROUND

Do you want stereo or surround? The choice isn't as simple as you might think.

If your budget is unlimited and you don't have troubles with space, then surround is the way to go. Games have surround sound tracks. Many of them make use of the increased directional information inherent in surround. Surround sound can be spookily engaging.

But ... there's always a but. If you have a

fixed amount of money you will need to decide whether it should be concentrated on a higher quality 2.1 speaker system, or spread out over an inevitably lower quality multichannel system. That will depend a lot on your use of your system. If you're gaming and only gaming, the balance likely tilts more towards surround. But if you spend half your time listening to music, better quality stereo is probably the way to go.

SURROUND CHOICES

With surround the options pile up. You can have 4.1, 5.1, 7.1 and now 9.1 and 11.1. The .1 is the subwoofer – that's not negotiable. Not only is it needed for the bass from the small main speakers, surround sound includes a 'Low Frequency Effects' channel dedicated solely to bass. If your game is going to rumble the air, it'll likely be contained in that channel.

The other figure is the number of main speakers. The defacto standard is 5.1, which has left and right stereo speakers, a centre channel speaker and two 'surround' speakers. With this configuration, the surrounds are mostly to your sides, just slightly to the rear. For years that was the standard for Dolby Digital and DTS (where available). But these standards all come from cinema, and so to some degree reflect the requirements of delivering sound to a lot of people in a very large room.

That's why there's a centre channel. If it's just you with your computer sitting directly in front of you, do

+ WHAT YOU HEAR – A PRIMER

The ideal computer speaker system will deliver the full range of sound that your ears are capable of handling, from the deepest bass to the highest treble. That frequency range is conventionally quoted as 20 hertz (aka cycles per second) to 20,000 hertz. As you get older, you hear those higher frequencies less well.

Most decent speakers will deliver the top end, but doing the deep bass is hard. Computer speakers without a subwoofer will struggle to get as low as 100 hertz. A compact subwoofer might get to 50 hertz. A sub capable of going 20 hertz and below with any authority at all costs in the region of \$2K.

As always, there's a trade-off between dollars and performance.

▼ Bowers & Wilkins
MM1 speakers



POINT YOUR SPEAKERS

Play with your speakers, especially on your desktop.

My current desktop audio system consists of a pair of extremely high quality KEF LS50 monitor speakers powered by an old Yamaha home theatre receiver, with a Krix Seismix One subwoofer sitting under the desk to handle the deep bass. But when I first installed it the sound was not at all what I had hoped for. The measurements were fine – even from 30 hertz to 20,000 hertz and more, and capable of astonishing levels – but the expected ‘near field monitor’ experience was missing. I wanted more from a system worth over \$3K.

The problem was that the speakers were firing right into my chest, rather than at my ears, and a large proportion of the sound I was hearing was reflections of the sound from the surface of my desk. The solution was simple. I sliced up some foam rubber packing and propped up the front of the speakers by about 50mm so that that were firing not horizontally, but up towards my ears.

That snapped them into focus and lifted the performance from okay to that of a world class near field monitor.

you even need a centre channel? The stereo speakers will create a virtual centre channel image (called a ‘phantom’ centre in the olden days of the 1990s). The main point of a centre channel is to locate the central sounds better for those people who are not in the ‘sweet’ spot for the main speakers.

And 7.1 channels is all about that large cinema. It adds two ‘surround rear’ speakers which are reasonably close together directly behind the listener. Its purpose: to locate surround sounds which are supposed to sound like they’re coming from the back of the room. They make little difference to the person who is sitting smack bang in front of a monitor in the correct position.

Any properly set up 5.1 channel system is supposed to mix down the two surround rear

7.1 channels is all about that large cinema. It adds two ‘surround rear’ speakers which are reasonably close together directly behind the listener

channels into the regular surround channels, so you shouldn’t be missing anything.

(‘Supposed’, ‘shouldn’t’, am I equivocating? Sure am. There are no guarantees that any given system will do the job properly.)

DOLBY ATMOS AND DOLBY SURROUND

And so surround sound rested for many years. But in the last couple something new has appeared: Dolby Atmos. This does two things. One is it fills in more gaps, but this time real gaps that offer something new for the solo user. Specifically, it delivers real overhead sounds, something that has been missing in surround thus far.

And it does something else that might be even more exciting for the future of gaming than it is for movies. Sound tracks have traditionally been finished products, so the placement of loudspeakers have had to largely conform to specification. A game might dynamically mix in play-specific items, but the underlying soundtrack was fixed.

Dolby Atmos does away with all that fixed stuff. In theory at least, the speakers can be wherever, and all the sounds can be placed wherever. There are up to 128 audio tracks, each with metadata specifying where its sound should be located at any instant. Everything can, potentially, be manipulated by the game.

In the home, Dolby Atmos can support speaker systems from 7.1 to ... 34.1. And even more in the cinema.

In practice, a Dolby Atmos system will be five or seven surround speakers and two or four height speakers. For a desktop system, two height speakers is likely enough.

Don’t worry: there’s no need to cut holes in the ceiling or bolt loudspeakers up there. ‘Atmos enabled’ loudspeakers are available which shoot sound upwards at the ceiling and bounce it down towards you.

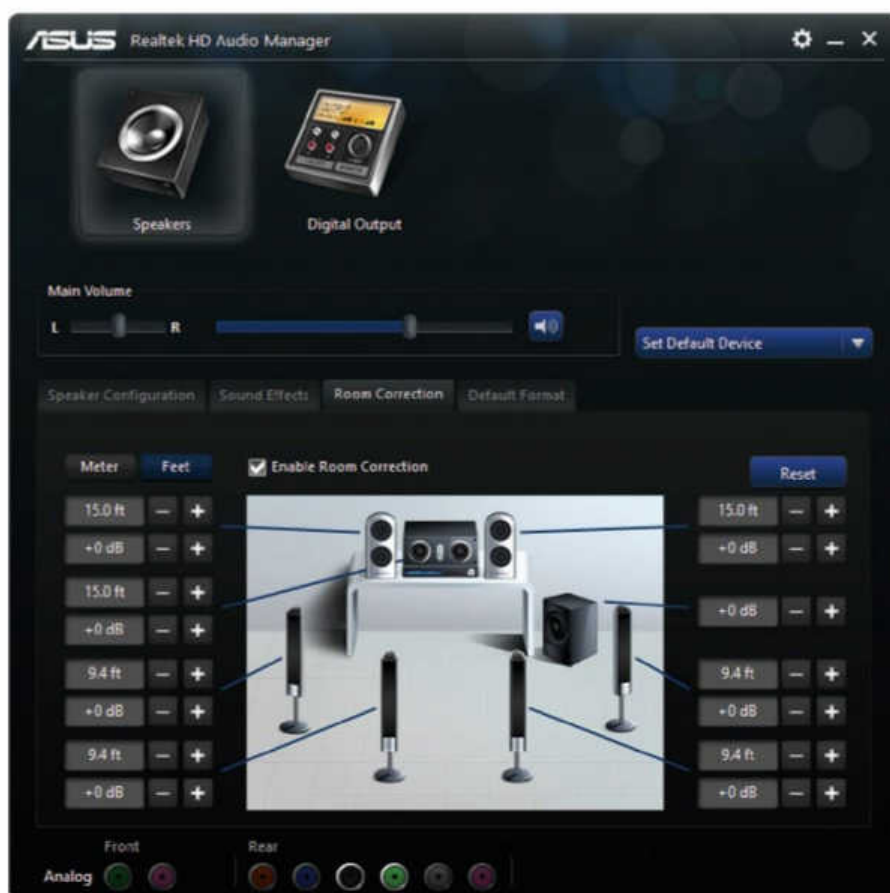
Along with the introduction of Atmos Dolby re-jigged its terminology and introduced a new sound processing mode called ‘Dolby Surround’, re-using the name of its very first home surround format which first appeared in 1982. This replaces Dolby Pro Logic IIz and its predecessors, processing two or multichannel sound into full surround sound including height.

There are problems with Dolby Atmos/Surround for the gamer: desktop implementations are implausible without applying a lot of money. It isn’t just a matter of the loudspeakers, the processor needs reasonable grunt to dynamically generate and allocate the necessary channels.

In the home theatre field a receiver capable of the minimum five surround/two height channels will set you back a grand or more before you start adding loudspeakers. You

KEF LS50 speakers





will need to get the Dolby Atmos audio signal out of your computer to the audio processor. Atmos uses Dolby TrueHD as its base, so your graphics card will need a HDMI connection (optical and coaxial aren't enough) which supports bitstream audio pass through to your audio system. Home theatre receivers are not compatible with high frame rate video signals, so your gaming will be locked into 60 hertz.

And then there's the question of games. So far only Star Wars: Battlefront, only just released, has appeared with Atmos sound (only in the PC version).

So, for the moment, Dolby Atmos is for gamers who are prepared to power their many speakers with a new, fairly expensive home theatre receiver.

TIME ALIGNMENT AND BALANCE

The main point of surround sound is to provide audible directional cues. But your sense of the direction of a sound is almost entirely determined by timing. Your brain has a powerful processor built in that compares the timing between sounds arriving at your left and right ears and calculates the direction from that. That timing difference is, at most, around one thousandth of a second (ie. a millisecond).

But sound takes time to travel. If your front left speaker is 800mm from your head and your

▲ Time alignment is required for accurate directional cues

surround left speaker is 1100mm from your head, the surround sound is going to reach you a full millisecond after the front sound. That wrecks the precision of the audible cues.

So any surround sound system must be placed so that all the speakers are the same distance from you. Nah, just kidding. The important thing is that the sound issuing from the speakers arrives at the same time. If the speakers can't be placed at the same distance, then the audio must be processed so that the sound to be delivered by the closest speakers is sound electronically delayed to correct the timing.

That is a standard feature of all surround sound processors, but even if you're using the surround processor on your motherboard, its control panel should have a facility to align the timing of the speakers (usually by setting their distances) and balancing their level. Modern home theatre receivers usually have an auto calibration system.

You plug in a microphone and the unit generates a bunch of test tones by which it

determines speaker distances, speaker levels and even EQ.

SPEAKER TYPES

Which brings us to the speakers that you need. By speakers I mean audio systems, for a speaker without an amplifier can do nothing.

You basically have a choice from four options, although you may choose to have both headphones and one of the others.

HEADPHONES

There are several advantage of headphones, some of them very obvious – ie. less annoying to others in the room or house. Another is that in terms of quality for dollar, you can't beat them. A set of astonishingly fine headphones will set you back less than a thousand dollars. For an equivalently good audio system you'd be looking at ten times that.

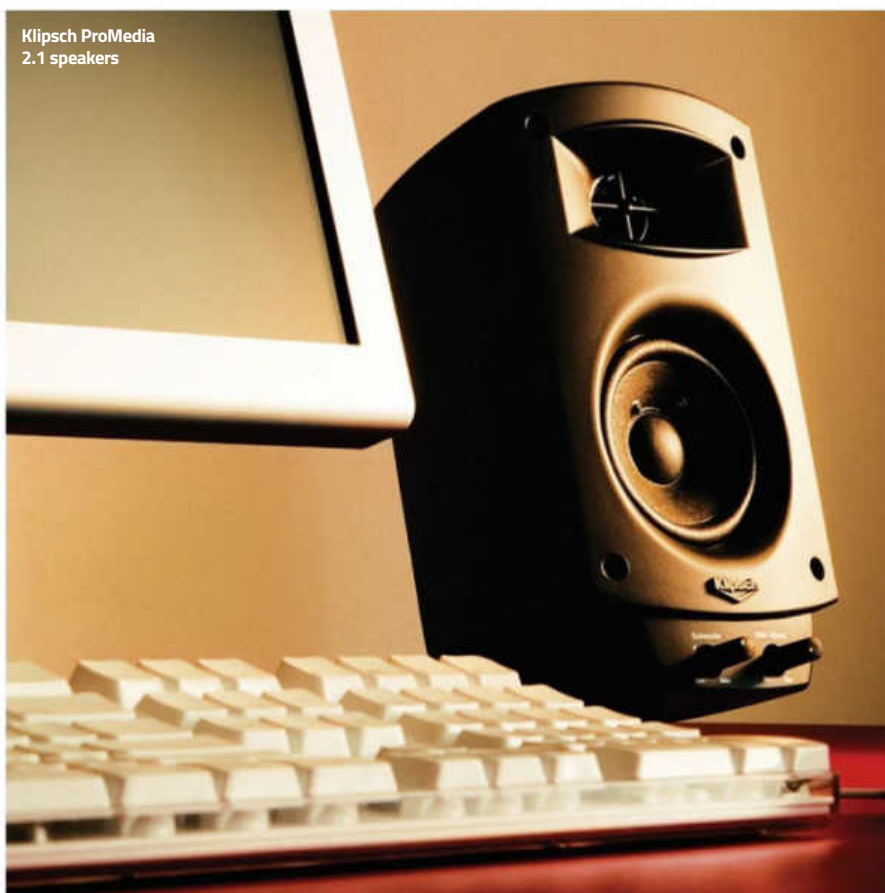
But beware: the better your headphones, the more obvious the weaknesses of the built in audio circuits in your computer. Pretty soon you'll want to get an external USB DAC/headphone amplifier to improve the sound.

There is also disadvantages to headphones. For example, as loud as you play them, you won't get the visceral impact that can be transmitted by a set of powerful loudspeakers and subwoofer. That affects your body as much as your ears.

There are surround headphones in addition to stereo ones. In fact, there are two ways that surround headphones can be implemented: by packing a set of headphones with multiple

▼ Audio-Technica ADG1x headphones





Klipsch ProMedia
2.1 speakers

Virtual surround is based on modelling how sounds vary depending on the direction they're coming from

drivers replicating in miniature a regular set of loudspeakers. Or by processing the sound to create a 'virtual' surround field with normal headphones.

The first way might seem like the best way, but that's far from clear unless the sound for each channel is processed by the headphone electronics. The reason things sound like they're behind you is because sounds seem different when they have to make their way around your ears and head, and there's some space required for that.

Virtual surround is based on modelling how sounds vary depending on the direction they're coming from. One of the better ones is Dolby Headphone, which was originally purchased by the US firm from a Sydney company called Lake Technologies. This can do a decent job of surround, and even stereo (it makes the sound appear to be coming from some distance in front of you), but results will vary depending on the individual. The modelling is for some kind of average person, but everyone has different ear and head

shape, and these are what modify the sound so that we can pick the direction.

Both kinds of surround headphones have one other weakness: part of the way we detect the direction of sounds is by how it changes when we move our heads. Since the headphones move with your head, that doesn't help in the slightest.

COMPUTER SPEAKERS

The quality range of computer speakers is extremely wide. There are many at the low end that should simply never be used at all.

The audio snob in me wants to insist that the 2.1 systems you can get at chain electronics retailers for around \$100, and the \$200 5.1 systems, should be avoided as well. But the truth is that there have been marked advances over the years so that some of these can deliver reasonable, if limited, performance. Their weakness will be in impact, overall level and the depth of the bass from their compact subwoofers.

You should look for a brand name.

Something like computer peripheral firm Logitech is one, of course, but there are also quite a few loudspeaker specialists that have special computer speaker model. For example, Klipsch, Bowers & Wilkins, Harman Kardon and plenty of others.

SOUNDBARS

Soundbars first appeared perhaps ten years ago to solve a home theatre problem: how to get surround sound without having to put loudspeakers all around the room. That was indeed the focus for quite a few years, with some incorporating more than forty little independently powered speakers to 'steer' the sound where it needed to be.

Perhaps. Sometimes. All of these depended a great deal on the types of acoustically reflective surfaces in the room, distances of the boundaries and so on. Surround performance was iffy. They would generally be able to give the impression of surround sound, but the direction from which sounds were supposed to be coming rarely matched how they were actually delivered.

In recent years, they've adopted a more realistic purpose: decent stereo sound from an unobtrusive package which can sit at the foot of an LCD TV, often accompanied by a subwoofer.

As with home theatre, I would not recommend them unless you've got significant space problems. And even then, I'd suggest 2.1 is going to be more flexible.

There are some smaller soundbars (the home theatre ones are typically 800mm to 1000mm wide) designed for use with computers. But, again, they lack flexibility.

HIFI SPEAKERS

Of course, if you're talking a lounge room system, you'll be wanting the best high fidelity speakers you can afford, along with a home theatre receiver. You will be using the system for movies and music in addition to games.

But why not consider the same for your desktop? The main advantage of computer





▲ Philips Fidelio Sound Bar



▶ Edifier Luna Eclipse stereo speakers



speakers is that they are very small. But do you have a bit of space on either side of your main monitor? Two hundred millimetres, or even a bit less, will do. Then consider a pair of compact high fidelity loudspeakers. And a home theatre receiver. And a subwoofer. You can start with just the speakers and receiver, and add the subwoofer later.

Advertisers: don't read this bit! Neither the receiver nor the speakers even need to be new, although you can get some pretty good deals. The receiver doesn't need HDMI inputs, just analogue and digital (coaxial and optical). eBay and Gumtree will have your needs at a reasonable price. As I write, there are compact speakers from Australian brand Krix and Danish brand Jamo at the top of the audio section on Gumtree from \$200 to \$400, and suitable home theatre receivers from \$20 to \$300.

A wise choice from there will deliver a more powerful, better sounding desktop audio system than almost all dedicated computer speaker systems.




◀ Paradigm Cinema 110 dual subwoofer speakers

BUYING

This article has spent a lot of time talking about the kinds of things to look for and the kinds of speaker systems which might best suit your needs. But it cannot make the final choice for you. If you wish to achieve a particular subjective effect – and believe me, with great speakers music and games both will be even more thrilling – then you're going to have to do some listening.

That means that in order to optimise your purchase you will need to come to an arrangement with a store that has speakers that might look like worth candidates for your system – unless you're buying second hand, in which case you'll have to google reviews. But with new speakers you want to be able to go into the store with at least some music that you know and want to get the best out of. And if you're gaming machine is portable, you'll want to take that in.

Then you'll want to listen at the levels you want to enjoy at home. Thus the need for an arrangement. You need to pre-arrange with the store so you can come in at a time when it isn't swarming with customers.

Most stores will be cooperative. Any that isn't clearly has insufficient desire for your money. 



WooAudio WA7 "Firefly" DAC

+ CONNECTIONS

The inside of a computer is an electromagnetic minestrone soup. Analogue audio circuits suffer in such an environment. Furthermore, while inbuilt sound facilities in many computers aren't too bad, they aren't the main focus of the computer maker.

So, ideally, you will get the audio out of your computer in digital format. That might be via HDMI in a lounge room system, but for a desktop system you should use optical or coaxial digital. That will handle multichannel audio in Dolby Digital or DTS format, and even high resolution stereo.

An alternative is a USB Audio DAC (digital to analogue converter), preferably USB Audio Class 2.0 (the device will come with a special driver for this). Such DACs can be extremely high quality, but are typically stereo only.

▶ Sound Blaster ES DAC



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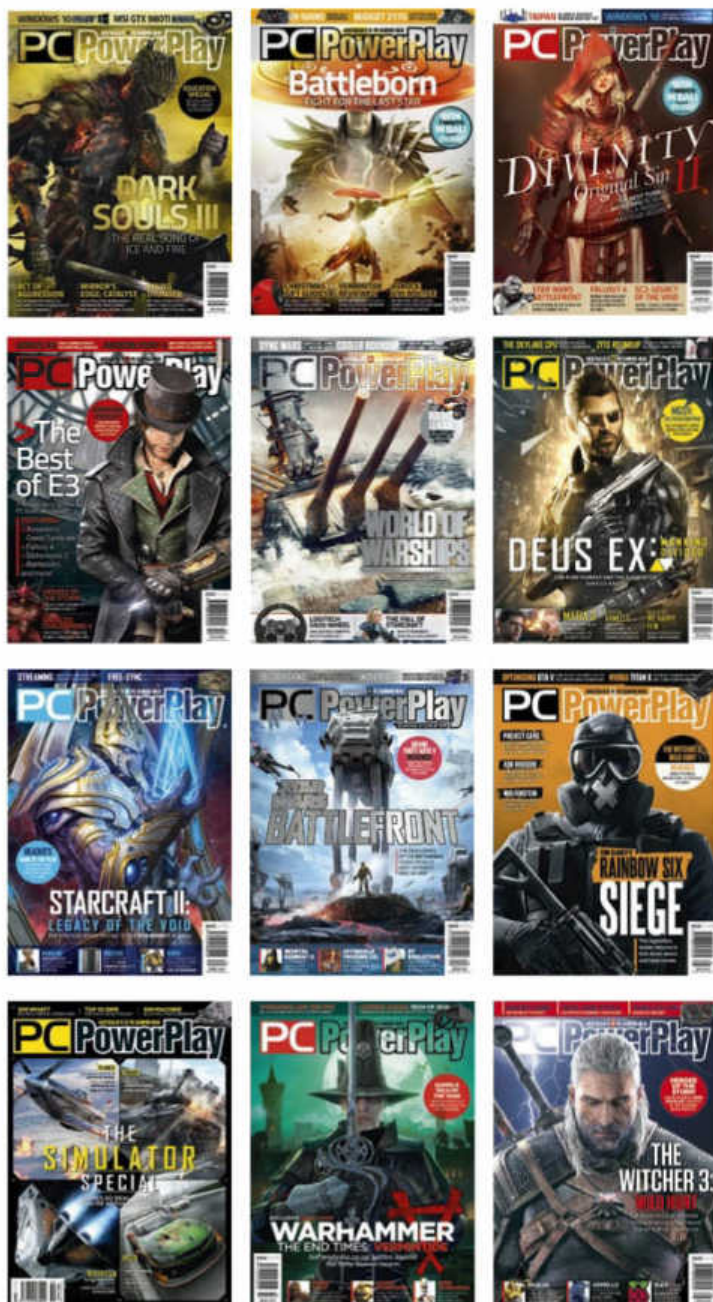
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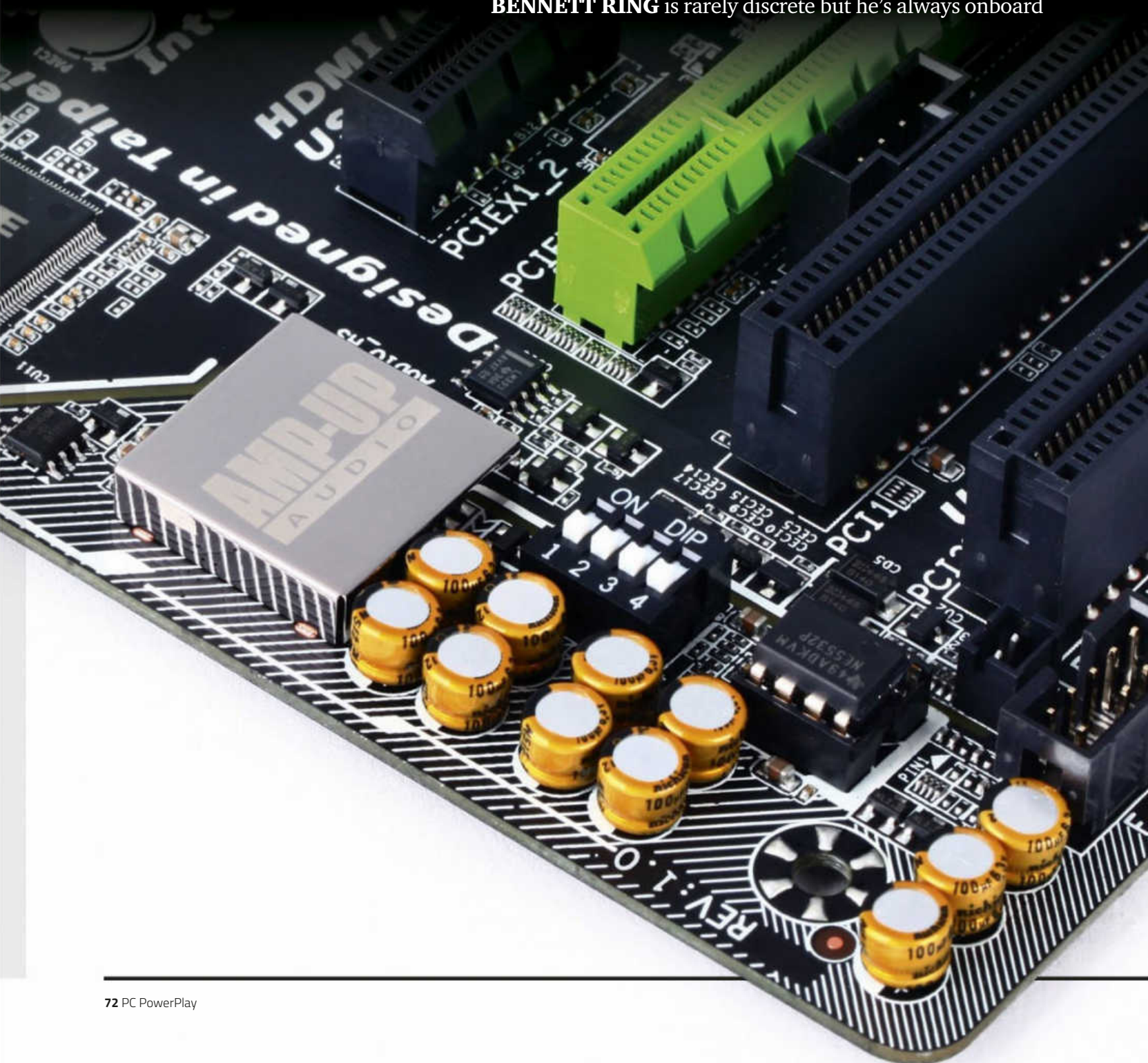
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THE GREAT SOUND DEBATE

BENNETT RING is rarely discrete but he's always onboard

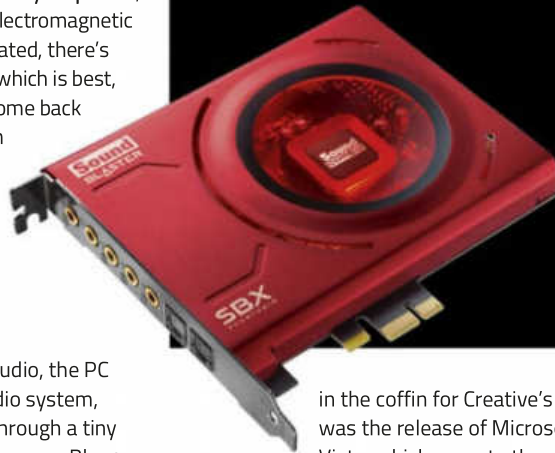


If there's one area of controversy when it comes to PC hardware, it has to be whether Perspex windows are now officially lame or not. Actually, that's not the one we're thinking of – we're referring to the old soundcard versus onboard audio debate. In one corner we have companies like Asus selling dedicated soundcards for between \$50 and \$320, whilst in the other we have companies like, well, Asus and all the other mobo makers claiming their new high-end onboard audio chipsets are just as good. Then there are the el cheapo motherboards that slap on basically the same audio chipset as the more expensive mobos, minus all the fancy amplifiers, capacitors and glowing lines of electromagnetic shielding. Like anything audio related, there's a huge amount of debate about which is best, which is why we decided to do some back to back *listening tests*, rather than the skulduggery of automated benchmarks that don't really prove anything. First though, a little history about how this debate all began.

LET'S GET CREATIVE

Back in ye olden days of game audio, the PC only had the most simplistic audio system, playing very basic sound chips through a tiny speaker glued to the inside of the case. Bleeps and bloops were about as good as it got, but that changed in the mid-90s. A few companies such as Roland and Creative started making dedicated sound cards, add-in boards that had processors designed solely to recreate digitised music and sound effects. It was a quantum leap of sound quality in the space of just a couple of years, similar to the massive leaps in graphics we saw when hardware T&L was first introduced on GPUs.

The market was dominated by Creative, a company that kept releasing newer, cheaper and better revisions of its hardware. Other companies like Gravis and Monster tried to compete, but Creative's early lead led to most games of the era natively supporting its proprietary audio APIs, such as EAX. Without one of these sound cards in your computer, you'd have no sound. Then in the late 90s, Intel introduced its AC'97 specification, an audio-codec that offered many of the features of these dedicated soundcards, yet could be easily included in the Southbridge of motherboard chipsets. This was replaced in 2004 by the Intel HD Audio standard, and by now several companies were building audio chips to support this, chief amongst them Realtek. Creative's cards were still doing strong, but over time Creative's business continued to be eaten away by the cheaper, simpler motherboard solutions. From 2000 to 2007, the dedicated sound card market dropped by over 80%. But the final nail



■ In 2015 the soundcard market is a mere drop in the bucket compared to the ocean of sales that it used to be ■

in the coffin for Creative's cards was the release of Microsoft Vista, which rewrote the Universal Audio Architecture of the Operating System. Creative's EAX suite no longer worked, despite some half-assed drivers released many months later. Microsoft's new audio system was much more regimented than the third party audio drivers, which had been one of the leading causes of PC problems for gamers, so removing the sound card often solved crashes. When combined with the powerful CPUs of the day and extremely cheap onboard audio solutions, most users deemed soundcards unnecessary.

In 2015 the soundcard market is a mere drop in the bucket compared to the ocean of sales that it used to be. Yet many still swear by their dedicated soundcards, with many enthusiasts still using five-year-old PCI cards rather than the onboard solutions that ship today.

SOUND SPECS

Before we get to our tests, let's look at some of the terminology used to promote today's sound solutions. As with most numbers, what can initially appear to be rather helpful when judging quality has since been manipulated by marketers to look good on the box.

■ Signal to Noise Ratio (SnR)

This is the biggie that you'll generally see first advertised when somebody is talking about a sound product. According to the peeps at Audio Technica, it's "The ratio, normally expressed

in dB, between the level of the desired signal and the level of unwanted noise". Basically, it should indirectly tell you how noisy a unit is – noise can also be described as hiss or static. Unfortunately, this statistic is so open to interpretation, and can be created in so many different ways, that it's basically meaningless. A device with an SnR of 120dB may have more hiss than one with 110dB.

■ Total Harmonic Distortion (THD)

This stat is meant to show how accurately a sound product reproduces a sound signal, and most manufacturers will list this as a percentage. Obviously 0.0005% distortion is a good thing, right? Well, not quite – most PC products only measure it at a certain signal. On the other hand, pro-audio equipment will test and disclose the harmonic distortion over the entire 20Hz to 20KHz range, so can't disclose THD as a single number – it needs to be shown as an average across that range.

■ Frequency Response

This refers to the range of frequencies that a device can replicate, and anything outside of this won't be recreated properly. The human ear is generally accepted to be able to hear anything between 20Hz to 20KHz, though some people can hear as low as 12Hz. Anything over 20KHz is a great number to have on the box, but not really meaningful

So now that you know that the main stats used to promote sound products are



▲ Asus Strix Raid DLX sound card

▲ Asus Z170-Deluxe motherboard

GIG GUIDE

We asked Dino Strkljevic, Marketing Manager for GIGABYTE Technology ANZ about how the company improved its onboard audio solutions over the years, and how they feel they stack up now. It's worth bearing in mind that Gigabyte don't sell dedicated sound cards:

"We looked at everything - from colour schemes, cooling designs, power designs, software, component use, good quality sound chips, sound isolation to headphone amplification... Another important change we made was an improved quality audio amplification and audio filtration (introduction of high-end capacitors which help filter sound at high dB). This has worked so well over the years that we can feel confident sending you a motherboard in \$1xx range up against a pro level sound setup."

▼ Gigabyte GA-Z170x Gaming G1 with Creative Soundblaster ZxRi chipset



basically meaningless, what should you look for to determine the quality of a soundcard or onboard audio? Luckily there are a couple of key factors here.

Quality Amplifiers

Any decent sound device will include additional amplifiers, and it's usually pretty easy to do a google search to find out if they're much chop. They may only cost \$10 or so per amp, but they can make a huge difference to the sound quality of a device. Some devices even let you swap out the amp, so you can find a tonal quality that you like, as all amps have a different aural flavour. If you're powering high-end headphones that require 600ohm of power, you'll need a device that can specifically handle this much power – not many low-end models can.

Quality Digital to Analog Converter, or DAC

This is the chip that does exactly what it says – converts the ones and zeroes into an analogue audio signal. Again, a quick Google search will reveal if the DAC used on your product is also used in high-end audio equipment, such as dedicated amplifiers. For example, the ESS ES9016 chip on the new ASUS Strix Raid DLX sound card is also used in some Pioneer amplifiers, which is a very good sign of audio quality.

Surprisingly, the audio processor itself isn't always a good indicator of audio quality. As you'll see in our tests, some of the most affordable processors pump out sound that is indistinguishable from far more expensive models, depending on the listening device.

GENERAL AUDIO TIPS

Here are a few tips to help you get the best audio, which we've learnt over the years.

1. If possible, use an external audio device.
The inside of your case is filled with many different electronic signals, which can cause interference and hissing. The "shielding" that we see on many motherboards and add-in cards generally isn't good enough to stop this.
2. For the very best audio, buy an external amplifier or AV receiver that can decode PCM audio over HDMI via your GPU. This way the pure digital signal is passed to an external box that will generally have much better quality components than a similarly priced sound card. It's possible to pick up a decent receiver for about \$350, the same price as a high-end sound card.
3. Don't buy a sound card if you plan on pumping out to your external amp via S/PDIF, as you may as well just use the onboard audio. It's a digital signal, so onboard will do just as well as a \$300 sound card. This author once made this mistake – never again!
4. Try not to use the front headphone port if possible. The long wire connecting this to your audio codec makes for a great antenna to pick up case interference.
5. Finally, the golden rule of audio. If you're using crappy headphones or speakers, it doesn't matter how expensive your amp or soundcard is, it's still going to sound pretty damn bad. On the flipside, a good pair of headphones or speakers can make a huge difference to listening quality, but may need a better sound source to work to their best ability.



▲ ASRock B150M Pro4 motherboard



▲ Audio Technica R70x headphones

▼ Corsair Void RGB headphones



HERE WE GO — EAR-BASHING

Now, onto our listening tests. We conducted blind listening tests with three different people – one serious gamer, one non-gamer and a muso who thinks he's got the hearing of Superman. We used three different sound sources, a PC running the new Asus Strix Raid DLX sound card, an Asus Z170-Deluxe with the high-end Crystal Sound 3 onboard solution (powered by the Realtek ALC1150 chipset spruced up with better amps and capacitors) and finally a low-end ASRock B150M Pro4 with a relatively basic onboard Realtek ALC892 audio codec. Two different playback devices were used – the Corsair Void RGB headset (\$140) and Audio Technica's wonderful R70x headphones (\$499).

Each listener then played a mixture of Battlefield 4, Witcher 3 and various music tunes in FLAC format, but the focus was definitely gaming performance. The results were, well, astonishing to say the least.

When using the cheaper Void headphones, all three listeners found it impossible to accurately state a quality difference between the sound card and high-end onboard audio. Our muso actually felt the onboard audio had the cleaner, truest soundscape of the two, while all three could not accurately nor consistently guess which was the dedicated sound card. Even when it came to the cheaper onboard solution, two of our listeners still found it impossible to accurately tell when they were listening to this, with our muso stating that music playback was inferior.

Next up was testing of the same devices with the far more expensive R70x headphones, and it was here that we started to see the difference the output device makes. All three listeners tended to rate the discrete sound card as the best audio device, though the onboard audio solution still did rather well, scoring 35% of the wins. All three listeners could immediately pick the cheapest onboard solution, across nearly all tests, but this could be because the headphones have 470ohms of impedance, which the onboard solution is not rated to handle.

We were going to do a final test with a Marantz AV receiver and 5.2 Paradigm Monitor speakers (total value over \$4000) but realised there was no point – the only correct way to use such a setup is to pass the PCM audio over the GPU's HDMI, which requires no sound card or onboard audio at all.

TO SOUNDCARD OR NOT TO SOUNDCARD?

We're confident that we've reached a solid conclusion with our testing – unless you're packing \$500 headphones, you'll be hard pressed to tell the difference between a decent onboard solution and an expensive sound card. And if you're running rather cheap headphones, around the \$100 price point, even the cheapest onboard sound solution will do the job. However, a more expensive sound solution tends to offer more features, such as external volume controls and better headphone surround. Music listeners are an entirely different case though, as are audio creators. We'll leave those tests to the Hi-Fi magazines. **PC**

+ POTENTIAL MISALIGNMENT

Asus sells both sound cards and high-end gaming motherboards with expensive onboard audio, so we asked them why they think their new high-end gaming sound cards are superior to the high-end onboard solutions used on their motherboards? Their answer pointed out that this isn't always the case, "This question and scenario isn't necessarily about a straight comparison of onboard vs discreet, but rather a look at usage scenarios and build specifications. On ASUS Republic of Gamers Maximus VIII Series (Z170) motherboards, a powerful and complete onboard audio solution, SupremeFX 2015, is present that is equivalent (or even exceeds) many discreet audio solutions, both from the ASUS product stack and competitors. This path was taken to allow increased flexibility for add-in card solutions – especially multi-GPU – that might squeeze out the opportunity to incorporate a discreet audio solution. In this sense ASUS engineers acknowledged that there was a potential for misalignment of spec and capability, resulting in a rhetorical design concept: who would want to run an awesomely powerful gaming PC and be stuck with poor audio because there is no space among the multi-GPU configuration? Any deserving gamer would answer "Not me!"



▲ ASUS ROG Maximus VIII with SupremeFX 2015

▲ LG 34UC97 Curved LED Monitor
– It's not actually mentioned
in the feature but it's so pretty
that we had to include it



THE WINDOW INTO YOUR GAMING WORLD

BENNETT RING never suffers from tearing

For the first time in as long as we can remember, gaming displays have actually experienced a shent-load of innovation over the last year. Whether it's high-speed IPS displays, wide-angled TN panels, G-sync vs Freesync, and the

confusing mess around Adaptive-Sync, gaming displays now come in more shapes and flavours than we ever thought possible. Here's our glossary of what all the different panels mean to gamers, and which features you should look out for.

TN PANEL

Twisted Nematic panels used to be the go-to guys for gamers. They were the cheapest to produce, and most importantly to gamers, had the fastest pixel response times. This refers to the time it takes a pixel to turn from grey to grey – if it takes too long, the image on screen will appear blurred, hence the term motion blur is bandied about when we test gaming panels. TN panels traditionally have extremely low pixel response times of 1ms, making motion blur non-existent. However, they're now rapidly being supplanted by better IPS panels, though TN panels are still widely used in the budget end of display pricing. BenQ's GL2460 is one such example – 24", 1080p and just \$180.

IPS PANEL

In Plane Switching panels are a more recent technology found in displays, and was first made popular in Apple's iPhone 4. It works quite similarly to TN in that it's still an LCD-based technology, but where the crystals in a TN plane are attached at one end, they can freely rotate in IPS. This gives it two massive advantages – much better colour accuracy and wider viewing angles. Stand a TN panel next to an IPS panel and the difference in colour vividness and accuracy is impossible to miss; the TN panel simply looks a little flat and lifeless. TN panels also suffer from colour and brightness shifts when viewed off-centre, even from as little as 40 degrees. On the other hand, all IPS panels can be viewed from an angle of 178 degrees with no colour or brightness shift.

Sounds good so far, but there are two issues with IPS. For starters, they're expensive – like, twice or thrice that of a TN panel. Secondly, their pixel-response times are sluggish, which can lead to noticeable motion blur. Well, that was true until about a year ago, but a new breed of IPS panels appear to have cleared this up entirely. This

■ If you've got some cash to burn, and a PC packing several GPUs, you might like to consider one of the high-refresh rate gaming displays ■



▲ BenQ's GL2460 TN Panel uses older technology to deliver size on a budget

is because they use the following technique, but they're still extremely expensive. Take the Asus PG279Q, a 27", 1440p, 144Hz panel with G-Sync. Asking price, \$1200.

OVERDRIVE

This feature is found mainly on gaming monitors, and relates to the voltage applied to each pixel. Basically, pixel response used to be measured by the time it took a pixel to change from black to white, and in this scenario, the maximum voltage was applied. Yet other colour changes didn't get as much juice, so took longer. Overdrive applies the maximum voltage to all colour shifts, and it's used to ensure the lowest possible pixel response time. This is how several IPS gaming displays now have pixel response times that come close to TN, such as the ASUS MG279Q, which is down to a 4ms response time.

VA PANEL

There's one last type of panel that can still be found kicking around in the cheaper aisles of computer stores. Vertical Alignment panels were big in the late 90s, but suffered viewing angle issues. Due to this, several types of VA panels were created, with varying acronyms: MVA, AMVA2, P-MVA and S-MVA. These have a few advantages in terms of extremely high contrast ratios, but they have one issue that makes them unsuitable for gamers – yup, sloppy pixel response times, usually close to 10ms, which is just not usable for fast games. They're good value for other uses though, like this Acer B276HL, a 27", 1080p panel for just \$320.

ADAPTIVE-SYNC

Note that this is totally different from the "Vertical Sync – Adaptive" (aka Adaptive Vsync) option that is found in NVIDIA's control panel (you can read what that does in our system tweaking guide). Adaptive-Sync is actually an optional part of the VESA DisplayPort 1.2a specification, and allows the display's refresh rate to be controlled by the graphics card, aligning each screen refresh with the creation of a new frame. This totally removes the need for V-Sync, and delivers a lag-free, tear-free gaming experience... most of the time. Adaptive-Sync is the technology that is the building block of AMD's FreeSync, and early versions of these monitors only supported a



▲ Asus PG279Q, a 27", 1440p, 144Hz panel with G-Sync IPS Panel



▲ The Acer B276HL features a VA Panel making it too slow for accurate gaming

dynamic refresh rate in a small window, say 40Hz to 78Hz. Thankfully newer FreeSync displays now support it much more widely, from 30Hz to 120Hz; outside of that the experience falls back to the same issues seen with traditional displays. With Intel recently announcing its support for Adaptive-Sync, you can bet your money that this will become the dominant form of adjustable refresh rate display in the near future. If your monitor has the Adaptive-Sync logo on it, it will work with AMD's FreeSync technology.

G-SYNC

This is Nvidia's proprietary version of Adaptive-Sync, but it only works on displays with a special G-Sync scaler when combined with an Nvidia graphic card, as opposed to the wide range of Adaptive-Sync scalars now on the market. This makes G-Sync displays considerably more expensive than Adaptive-Sync displays, but has allowed Nvidia to ensure the overall experience is much more consistent. This is why G-Sync was the favoured solution for early adaptors, but it seems that Adaptive-Sync has now made headway, resolving many of its early issues. Unfortunately

Nvidia has refused to comment on whether it will ever support Adaptive-Sync, or the DisplayPort 1.2a standard necessary for it, which would make buying a new display a much simpler choice for everybody. We don't blame them for trying to protect their multi-year investment into G-Sync, but when the rest of the world moves onto a new standard, perhaps it's time to cut your losses?

HIGH SPEED GAMING DISPLAYS

If you've got some cash to burn, and a PC packing several GPUs, you might like to consider one of the high-refresh rate gaming displays. Where most gaming displays still run at 60Hz, these greyhounds of the gaming display world jack it up to 120Hz, 144Hz or even 165Hz. The biggest benefit is that the appearance of motion just looks so much smoother. If you've never seen one of these screens, a good analogy is the 48Hz version of *The Hobbit*, which ran at twice the framerate of traditional frames. However, unless your GPU is capable of pumping out 100+ frames per second, you won't see this benefit.

Secondly, you can leave V-sync off and not have to worry about screen tearing, as your framerate is unlikely to exceed the monitor's refresh rate. Secondly, if it does, the screens are being updated so quickly that tearing is harder to notice. Be warned though, once you've gotten used to 120Hz, heading back to 60Hz feels sluggish, and the hardware costs to maintain 120fps in newer games at higher resolutions is *substantial*.

▼ The ASUS ROG Swift PG348Q curved display features an IPS panel



► G-Sync and FreeSync work similarly, but the proprietary nature of G-Sync makes it more consistent across different monitors

CURVED DISPLAYS

Curved TVs make absolutely no sense unless you like to sit within 20cm of the screen. Funnily enough, most PC gamers do sit relatively close to their display, which is why curved gaming screens make so much more sense. With a new breed of 34-inch, 21:9 curved gaming displays on the way, now is a very good time to consider the tech. Be warned though – if they're using a TN panel, the colours can shift towards each edge. That's why we're so excited about the new ASUS ROG Swift PG348Q display, as its 34-inch screen uses an IPS panel with a cracking resolution of 3440 x 1440. We're guessing this won't be cheap.

ULTRA WIDE PANELS

These displays usually use the 21:9 screen ratio, making them much wider than normal panels. We've never really been fans of these at PCPP for one major reason – they usually used a TN panel. When you're sitting close to a TN panel that is 34 inches wide, it's easy to spot the colour shift on each edge of the panel. These displays seem to be getting replaced by the curved, IPS versions mentioned above. **PC**



A pixel art illustration of a fantasy landscape. In the foreground, a winding path leads through a valley. In the mid-ground, a large, multi-towered castle or fortress sits on a hill. The background features rolling hills and mountains under a sky with soft, horizontal bands of color, suggesting a sunset or sunrise. The overall style is reminiscent of classic 8-bit or 16-bit video game graphics.

SO YOU WANT TO MAKE A GAME

THE ULTIMATE BEGINNERS GUIDE TO GAME DEVELOPMENT

Making games takes a lot of time and effort - but with the tools available in 2015, it's never been easier. **DANIEL HINDES** tells you everything you need to know to start thinking about games not as a player, but as a creator.

Interested in making a PC game? That's cool. So am I! In fact, I started doing so a little over a year ago, with absolutely no experience whatsoever. If you're in the same position and have no idea where to start, this is the guide for you. But don't raise your expectations just yet: reading this won't give you the power to make an entire game right away. It is a long, arduous and often tedious process. But you can do it. I believe in you.

What can you expect to do after reading this, then? You'll have a starting point. You'll be set up and ready to go with all the tools you need to begin. You'll understand on a conceptual level all the elements that make up a basic game, and how they interact with one another. And you'll get to this point without even having to write a single line of code.

NARROWING YOUR OPTIONS

The most incredible thing about game development in 2015 is that most of the creation tools you need are free. Everything from the game engines themselves to third-party image and audio editors can be used without spending a cent. However, with so many options available, the first thing you need to do is decide what kind of game you want to make, and thus, what tools would be most appropriate to make it with.

The first thing you need to decide is the engine you're going to use. As your first project, I strongly discourage you from making a 3D game. Working with 3D adds quite literally a whole other dimension of complexity over 2D, which ripples out to make every other aspect of game development more time-consuming. It's much harder to prototype a game in 3D; you'll spend far more time tracking down bugs; compiling and testing takes longer and requires far better hardware.

For this reason, I recommend picking an engine that focuses on the creation of 2D games. Though engines such as Unity 5 do let you make things in 2D, they kind of fake it by making a 3D room and showing it from a 2D perspective.



You'll also want to use something that's incredibly friendly for beginners. Twine, for example, is incredibly easy to learn, though it focuses entirely on the creation of choose-your-own-adventure-style text-based games. Fun fact: the story for Telltale's The Walking Dead was prototyped in Twine!

But if you want to make something that's more akin to other traditional genres, such as a platformer or a top-down shooter, I recommend starting with GameMaker: Studio. It's perfect for both the creation of simple 2D games, as well as for teaching you the fundamentals of how games themselves are actually made.

IT'S WHAT'S INSIDE THAT COUNTS

One of the first things you'll need to come to terms with is the fact that your game is going to look awful for a long time. This is because you'll be building a prototype, not a finished product - and you'll be building it as quickly as possible. You're going to be using different coloured squares, circles and triangles to stand in for enemies, walls, weapons - basically everything in the game.

You'll be doing this because changing and removing things that don't work from an abstract masterpiece is far easier to do than from something that has actual polish and graphical fidelity thrown into it. You won't be as attached to what you've created, and will be more willing to delete entire sections of game logic - which is something you definitely will be doing.



A BIG LIST OF ENGINES

UNITY 5

www.unity3d.com

Free, great for 3D games, moderate 2D game support. A big feature is the Marketplace, where you can buy assets and plug them straight into your game.

UNREAL ENGINE 4

www.unrealengine.com

Free, but you need to pay a licensing fee if you release something. Mainly 3D games. Amazing graphics out of the box.

TWINE

www.twinery.org

A simple-to-use tool for creating text-based multiple-choice adventures. You'd be surprised what you can do with just words.



CONSTRUCT 2

Allows you to create simple 2D games with minimal experience. The only limitation, however, is the size - the games are quite small.

GAMEMAKER: STUDIO

www.yoyogames.com/studio

GameMaker also allows you to create 2D games, but they can be much larger. Hotline Miami and Gunpoint were made with this.



The idea is that you want to implement the roughest yet most complete version of any new design idea as quickly as possible so that you can test it to see if it's fun. Very rarely does something only become fun after its final graphics and "gamefeel" tuning has been applied. You'll at least sense a glimmer of fun with a mechanic, even when you're working with squares and circles.

Once you have implemented something rough, don't be afraid to adjust its associated values to outlandish proportions, just to see what happens. If you're making a platformer, and the jumping doesn't feel good - what does it feel like if it were five times faster? Or if you jumped twice as high? Perhaps enemies need to move half as quickly, while your running speed would feel better at 300%. It takes seconds to tweak these values, and the chance that you'll stumble upon a combination that feels great is higher than you'd suspect.

THINKING OBJECTIVELY

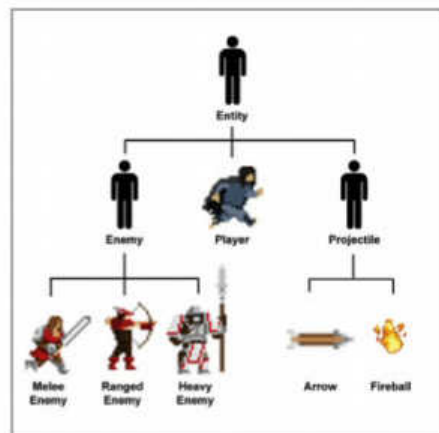
Now that your expectations are set, it's time to learn about how games actually work. I'm not talking about the actual code itself - rather, I'm talking on a more abstract, conceptual level. George Broussard, the creator of Duke Nukem, once boiled this down by saying that games are about creating an Object, moving that Object, and then destroying that Object.

Take a moment to think about that. Pac-Man is created, moves around the board, and is eventually destroyed by a ghost. When you fire a gun in a game, a bullet is created, it moves along a trajectory, and is then destroyed when it hits a wall or an enemy. You create a Marine in StarCraft by building it in a Barracks, then moving it to the enemy base, where it's eventually destroyed by a swarm of Zerglings.

The key word here is "Object"; it's the most basic building block of any game. Think of Objects

like the bricks in a Lego set. But in game terms, what is an Object? It can be anything - a character, a weapon that character holds, the bullet that weapon fires, the wall that bullet impacts, the shards of debris which fly out of that wall when it's hit. If a "thing" exists in a game, that thing is likely an Object.

Objects have a special property called Inheritance. A "parent" Object can have many "child" Objects, all of which inherit the parent's properties. For example, if your game has different types of enemies, but you want all enemies to chase after the player once they get close enough, you would create a parent Enemy object which handles the chasing code. Then, you would create a number of child enemy objects - such as an enemy with a melee attack, and another with a ranged attack - but all would inherit the ability to chase the player.



You need to think very broadly about Object inheritance, because planning it out will save you a lot of sweat and tears in the long run - even for a prototype. It's worth drawing a diagram, such as the one here.

What you want to do is create the ultimate parent - a "super" parent,

+ FREEDOM ISN'T FREE

GameMaker: Studio isn't entirely free. The trial version, which you can use to do the basic tutorials with (which is enough to get a sense of whether you want to keep making games at all) is free. However, it limits the total number of Objects you can create. You can purchase the full version for \$99 on Steam, which allows you to export your game to PC. Exporting to other platforms, like Android or Mac OS, costs more money on top of this.

if you will. This is an Object that handles behaviours which can apply to every single other object in the game. Think about that for a bit. What does every Object in the game get affected by? The answer, as in the real world, is physics (Hey, quantum physicists, keep quiet - I don't want to hear it). But a full, dynamic physics system like the one seen in Half-Life 2 is much too complicated for your first prototype, so let's strip it down to one, single aspect of physics: gravity.

Without gravity, if your character jumps, they would never fall back down. Creating gravity in a game is as simple as saying "If my character is in the air, make them fall downwards until they collide with something." This brings us to the other thing this super parent Object needs to handle: collision. A collision "event" happens every time one object touches another object. If a character who is falling with the force of gravity collides with the ground, that collision event needs to say "stop this character from falling any further down" - otherwise that character would fall through the floor. Similarly, if that character is walking left to right and they hit a wall, that character needs to stop moving, otherwise they would walk through the wall. Every time you use a "noclip" cheat in a game, you're stopping these kinds of collision events from happening.

FOR INSTANCE

So, we have gravity, and collision. Two fundamental aspects that form a basic physics system, and all of these are being handled by a super parent Object. Let's call that object "Entity" - because it serves as a general template. Now, it's time for Entity to have some children.

The first child we want to bring into the world is the Player. This is the Object which you will be controlling. It will





GOING TO MARKET

You don't have to do everything from scratch. GameMaker has its own marketplace, found at www.yoyogames.com/marketplace. This is where other developers post pieces of their games for you to buy and plug into your own. This can mean anything from snippets of code, entire multiplayer networking systems, character sprites, sound effects, or environment art. Have a browse before you spend weeks trying to get something to work on your own!



inherit Entity's properties, so it will fall with gravity, and stop moving when it touches the ground or a wall. For most games, you will only ever control one player character at a time - and there will only ever be one version of that player character that exists in the world. In development terms, this means there will only ever be one "Instance" of the Player.

However, games usually feature multiple enemies to overcome. But you don't want to have to create a new Object, and remake all of its behaviours, for every new enemy in a level. Thankfully, you don't have to! An Object is essentially a template with which you use to create Instances of that Object.

Think of an Object like a star-shaped cookie cutter. Every time you press that cookie cutter into the cookie dough, you are creating an Instance of a star-shaped cookie. And you can use that cookie cutter as many times as you want to create as many star-shaped cookie Instances as you want.

This means that the next Object we want to create is an Enemy. This Enemy will also be a child of Entity, because we want that Enemy to inherit our gravity and collision behaviours. And we will use this Enemy to fill the level with multiple Instances of itself.

WIBBLY WOBBLY

In this conceptual game which we are building in our minds, we now have a level which features a Player, multiple Enemies, and all of them are affected by gravity, and understand that they should stop moving when colliding with a wall or floor. Now we need to talk about how games handle another universal phenomenon: time.

Without time, the Player and the Enemies would remain frozen in place, unable to move. Gravity wouldn't even come into effect without time. But how does the game measure time? In much the same way we trick ourselves into measuring time in real life.

An Object is essentially a template with which you use to create Instances of that Object

Let me explain. In real life, time is constantly flowing forward. We divide a day into hours, hours into minutes, minutes into seconds, and so on, because that makes time easier to measure. But you can keep going smaller: seconds become milliseconds, then microseconds, then nanoseconds - too small to be useful in daily life.

In games, time does flow forward, but at a very real, constant, and measurable rate. You know how games run at a certain frames-per-second value - usually 60, if it's running well? Each one of those 60 frames is a distinct unit of time for a game. This is why games with a higher frame rate feel more responsive. Each unit of time is a chance for an action in the game to take effect. For example, if you quickly stop moving to the right and start moving left, the game has 60 opportunities each second to process that and reflect it in the Player Object's movement. In GameMaker, this unit of time is called a "Step".

This is also why some games restrict themselves to running at 30 frames-per-second - because they only need to process half as much information every second. If you think about how many complex things can happen in a single second of an open world game like Grand Theft Auto V, and then realise the system needs to compute that 60 times every single second, you can start to understand why some games are so hardware-intensive.

What does this mean in practical terms? Well, remember those maths problems you had to solve in school - "A train leaves the station at 12:40pm, travelling at 20 kilometres an hour..." et cetera. Everything you do in a game that involves time feels like solving one of these puzzles. Let's pretend our Player is moving at a speed of 4. The "4" measures pixels - which means that for every Step, the Player moves 4 pixels across the screen. If there are 60 steps every second, how long will it take the player to move an entire screen resolution's width of 1920 pixels? Spoiler alert: 8 seconds.

THE NEXT LEVEL

Let's go over what we've learned so far. We know that any "thing" in a game is called an Object. We know that Objects can Inherit properties from other parent Objects.

Because of this, we can start building a lineage of Objects, in which the force of gravity affects all of them, and where upon colliding with a solid wall or floor, they stop moving. We know that Objects are just templates with which many Instances of that Object can be created. And we know that time in this game is measured in very discreet Steps – 60 of them for every real-world second.

These are all the basics you need to understand to start making a game. They are aspects which you need to take into account every time you design a new system. For example, when you make a new Object, think about how it fits into your Inheritance. What should its parent be? Should every weapon that you can pick up have a parent Object, like “Pickupable”? Should every different type of projectile – bullets, arrows, fireballs – all inherit the properties of a generic “Projectile” Object? Generally, yes. And when you’re designing the behaviour of the way those projectiles move, keep in mind how the game measures time, and how the arc of those projectiles is going to be affected 60 times a second.

Where do you go from here? It’s a simple path, really. Start working through the “Basic” level tutorials included in GameMaker itself. What I’ve taught you here are the conceptual fundamentals; those

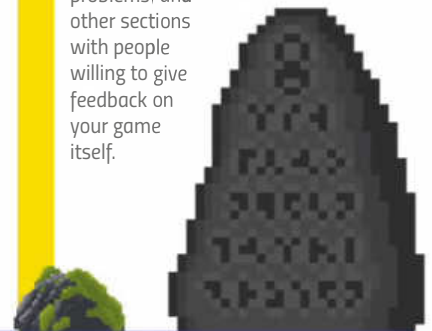


tutorials will teach you how to implement them in a practical sense. Once you’re done with them, I highly recommend making a small and basic sidescrolling platformer. This will teach you much stronger fundamentals than the included GameMaker tutorials will. Luckily, YouTuber Shaun Spalding has created a YouTube tutorial series which walks you gently through everything you need to do. Check it out at <http://tinyurl.com/platformertutorial>.

With that, you’re ready to go! Chances are, as you’re working on these tutorials, you’ll come up with ideas for things you’ll want to implement in your own prototype. Write these down and store them away, to come back to once you’re feeling competent enough. And don’t be afraid to put your own little spins on the tutorials’ instructions, too – deviating from the norm and coming up with something creative is what this is all about. Good luck! 🍀

+ WHERE TO GO FOR HELP

No matter what engine you use, game development communities are usually very accommodating of newcomers and willing to help with any problem you might be having. For GameMaker, check out the community forums at <http://gmc.yoyogames.com>. They have specific sections for programming problems, and other sections with people willing to give feedback on your game itself.



SO YOU WANT TO BE A PROFESSIONAL GAMER?

DANIEL WILKS is way past his prime

It's not too much of a stretch to say that anyone who loves playing games has at some stage fantasised about the idea of making money playing game, of turning their hobby and passion into a career. Rather than trying to dish out some advice on how to make that dream a reality ourselves, we instead reached out to a number of professional gamers from Australia and around the world to find out how they made the move from amateur to professional, how they found their teams, why they chose their particular games and more. Here is what they had to say.



Taipei Assassins lift the Summoner's Cup after winning the League of Legends World Championship Season 2

Q: WHAT DREW YOU TO YOUR CHOSEN GAME IN THE FIRST PLACE?



Simon "Swiffer" Papamarkos – Team Captain of The Chiefs (LoL): What drew me to the game was, firstly, already having a preference for MOBA-style games, having played DOTA in the past and enjoying it thoroughly. Secondly, the fact that all my friends simultaneously decided to stop playing DOTA and switch to LoL basically sealed the deal.



Jared "PiG" Krensel – Exile 5 (StarCraft 2): I was first drawn to StarCraft due to my history playing RTS games growing up. A lot of the biggest games, and especially many of the best multiplayer games, were RTS growing up. Games like Command and Conquer, Warcraft Orcs and Humans and Warcraft 2 were all huge parts of my childhood. I also lived through the internet cafe craze in the early 2000s where we would all go down there to play counterstrike, Warcraft 3 custom maps, StarCraft 1 and later DotA. The mix of loving playing RTS since I was very young, competing vs my brother and friends, as well as the competitive nature of LAN play, all led to me really loving playing games competitively – even though I'd never heard of the professional gaming scenes outside of vague stories I'd heard about Koreans playing StarCraft on TV.

In 2010 I had just been getting back into competitive gaming with a lot of HON and DotA for 6 months leading up to it. Having to rely on team-mates in order to improve was starting to frustrate me, as I found myself outgrowing my friends competitively and having to spend most of my time being the diplomat getting people to work together, and try to make up for other players' mistakes. So when StarCraft came out and I got to improve on my own and every win was purely from my own efforts, every loss my own fault, I found it really refreshing. I found it much easier to strategise and pinpoint areas to improve than in team games and fell in love with the never-ending quest for improvement in the most challenging game ever made. Soon after I got into it, my friends introduced me to The Global StarCraft League run by GOMTV, and all the amazing tournaments with great commentary by eSports veterans, opened my eyes to true understanding of StarCraft; how to analyse and break down the game and understand the thousands of moving parts that contribute to the pinnacle of RTS gaming. From there I was completely hooked.



Helene "Faith" Schulz – CM Storm (CS: GO): I chose to play Counter-Strike because I started to play Half-Life

offline when I was younger. My brother, cousin and I played all day long. When we got internet I found another game like Half-Life that I could play with other people online. That's how I chose Counter-Strike 1.5.



Lachlan "Sybol" Civil – Dire Wolves (LoL): My first MOBA was Heroes of Newerth which I played in the beta

back in 2010 before being told about League of Legends by a friend. I was never really a big MOBA player coming from a background of WoW and PC Shooters like CoD, CS: Source and Battlefield. But I loved the gameplay style of fast brawly action that MOBAs had and really enjoyed following the competitive scene as well.



Tim "Carbon" Wendel – Team Captain Legacy eSports (LoL): I originally played a custom StarCraft 2 mod that

emulated DotA. League had begun to gain some popularity around the same time and me and my friends figured, why not play an actual MOBA instead of just a StarCraft mod?



Kelly "KllyVe" Verhaegen – CM Storm (CS: GO): I started playing Counter-

Strike source because of my brother, He was always playing it and I was really interested and started playing it as well. I didn't start playing CS: GO right when it came out, but jumped in just a few months after the release.



Riki "Yada" Wellington – Dire Wolves (SMITE): I first saw the game on the

Halloween livestream done by The Creatures in 2012. I had no prior experience in MOBAs, and both the gameplay as well as the mythological characters I saw really interested me. After finding out that the game was free I signed up for a beta key the same day.



Daniel "Rowe" Rowe – Avant Garde (SMITE): Smite lured me in because of

the unique aspect it took on a MOBA with the POV. A 3rd person POV was something I always liked from my World of Warcraft years, so combined with the competitiveness of Smite it was an easy choice.



Lucas "Glaive" Rossander – CM Storm (CS: GO): When I was around 10

years old, my brother sat playing Diablo 2 with one of his friends. I sat next to him for A LOT of hours and he taught me how it all worked. Then I started playing Counter-Strike in the youth centre with my friends. Every time I played Counter-Strike I felt a happiness inside me, a happiness that nothing else could bring. One day passed into another, with me sitting in front of my computer, just playing all day long.



Kurtis "Biggy" Davidson – Avant Garde (SMITE): Two of my best mates

and I used to play a lot of different games together and then one of them discovered Smite and told us we should check it out, so we did. I really didn't like the game at all but it was strangely addictive so I kept coming back.



Q: WHEN WAS THE POINT YOU DECIDED YOU WANTED TO TURN PRO?



Swiffer: The point I decided to turn pro wasn't really a decision that I reached on my own. It was something that just somehow came about. I was offered a position on a team but never entirely understood that I'd travel or become a legitimate 'pro'. The first time that I actually felt somewhat 'pro' was when the OPL was introduced and games were standardised, formalised and legitimised.



Faith: I had wanted to be pro since I started female gaming and found out that you can compete with your team at tournaments like the ESWC. I had always wanted to play at big events and now I do more than ever, especially since the scene has grown.



Caren Tiger – World of Tanks team: I wouldn't call us a pro team, but as long as we've been together we've wanted to go up against pro teams. Our first step was probably in November 2013. At the time, there were some pro teams in Asia, but they all seemed to be at the starting point of their careers.

We took a lot of inspiration about strategy from Russia. However, because of the lack of training, we were not as strong as we could have been. A short time later, after continuous training, we started to see improvements to our style. Then, eventually, we could start challenging the lower teams in the rankings and slowly making a name for ourselves.



Yada: Months before the first Pro League for Oceania began, I would solo queue casuals and often end up against both former and current pro players from the region. I remember when one of those teams was first picked up by their sponsor it made me really feel as though I could be doing more, as I felt I could definitely compete at their level.



Mitchell "Destiny" Shaw – Avant Garde (LoL): I decided to go Pro when I realised I was better than what I thought I was. I worked hard to climb the Solo Queue ladder and continued to improve myself. When my father passed away, I put all my motivation into League with the intent to make my name known and to make him proud.



Sybol: I played League pretty casually with my friends and my brother for a long time and it wasn't until midway

through season 3 that I started playing ranked just because a friend wanted to duo. I don't think at any point I was playing to become a 'pro'. I was really just playing ranked because I wanted to see how good I could get.



Inki "RedBull" Park – KONGDOO (World of Tanks): The team is yet to make this decision. For now we are competing on an amateur level. We're not ready to turn gaming into a full-time thing. Hopefully, at some point we'll go for it.



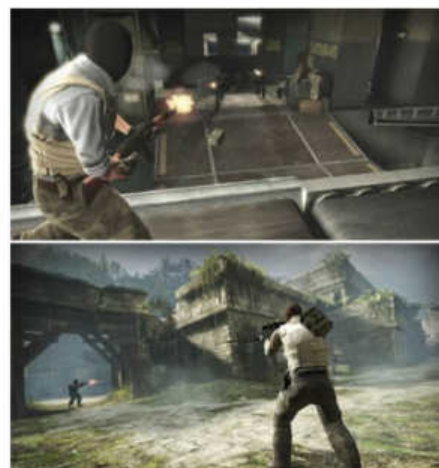
KillyVe: When I saw live streams of tournaments like Esl One or Dreamhack and I saw the stages, the supporters and the fans screaming for their teams. Those are the moments that made me sit silently for and think, "I really want to be on that stage." I want to have awesome fans that scream my name. I felt really happy when I saw these moments. That's when I decided I wanted to become a pro.



Nikolo "Porky" Tayag – Avant Garde (LoL): I never decided to turn professional, I just played with friends and eventually we just got better and I ended up being one of the top players in Australia.



Biggy: I always thought playing on a team would be kind of cool but never really considered becoming a 'pro'. Eventually I formed a team just to see what it would be like. We were very successful and the scene kind of grew naturally to the point where we were all very lucky to become professionals in the game.



Glaive: When I first found out that there were events in Denmark where you could compete against other teams, I was hooked. I started playing on a team with some friends I met online and suddenly I was on the other side of Denmark competing against these other teams. We lost almost all of our games, but I sat for 10 hours behind the pros and just watched them play and listened to their communication. At that point I knew I had to work hard to become one of them.



Carbon: It wasn't so much a decision as much as a set of favourable circumstances. I just played the game for fun but over time I got pretty good and managed to achieve rank 1 on the oceanic servers. This had gotten me noticed and one day I was asked if I would be interested in trying out for a new team that was being put together. Even as a "pro" player my first team never really took it too seriously, we just went to events to have fun. It was after the first big regional held by Riot that we as a team decided we actually wanted to win. I suppose I would call that the start of my actual career.



Q: AT WHAT POINT DID YOU REALISE THAT ACTUALLY BECOMING A PRO-GAMER WAS ACHIEVABLE?



Samuel "Spookz" Broadley – *The Chiefs (LoL)*: After I had climbed elo on NA server and was high relative to the OCE players I felt like it was worthwhile to pursue competitive play



KillyVe: When I played my first female tournament and we ended up in a decent place I was like, "This is really achievable, to get to the top of the best female players." At the time, I thought that we just needed some more practice and more experience and we would make it to the top.



Yada: I had a lot of support before ever joining any proper teams from some of the players I believe to be the best in the region, in the form of being encouraged to join/form teams or being their substitutes for their own practice. That practice is when I realised that I could compete with the best of Oceania.



PiG: I think it was towards the end of that same university holidays (end of 2010/start of 2011) when I surprised myself by winning a local charity



tournament at an internet cafe. The only prize was a bunch of credit at the internet café, but there was something about the atmosphere there that I still remember very clearly; everyone was so excited and caught up in the intense atmosphere of competition. I remember playing the finals and having a small crowd watch over the shoulder, cheering and gasping as I smashed away at my keyboard and clicked furiously. I had never felt a rush like winning that finals before, and I think it's what really pushed me into seriously wanting to become a pro.



Carbon: It wasn't so much realising I could become a pro as much as realising what a pro could actually achieve. I've been at the top of the ladder

basically since OCE came out as a server so I was always aware I could play at the highest level in the region. The big realisation came for me when I was took the opportunity to go to Gamescom in Germany to represent OCE. That being a pro could provide me with something tangible was a big moment in my career.



Michael "Friis" Jørgensen – *SK Gaming (CS: GO)*: To be honest, I never thought that good about myself. But everyone else hyped me up in Denmark and I ended up being the star of every team I played in. I never considered myself any better than my team mates - Counter-Strike is a team game after all. The team is only as good as its teamplay as it's all about coherence. Eventually, one of the world's most recognized teams reached out to me and asked if I would want to sign a contract and join up to compete with the best - I didn't have to think twice and took the opportunity.

“The only prize was a bunch of credit at the internet café, but there was something about the atmosphere there that I still remember”



Q: WHAT WAS THE FIRST STEP YOU TOOK GOING FROM A NORMAL PLAYER TO A PRO?



Faith: My first step was to play with a serious female team, to train hard with them and compete at tournaments. This was no longer the play of a mixed fun team.



KillyVe: I had to make a decision about whether to be a pro player or just play for fun. If you want to be a pro player then you have to act like one that is how I saw it. It is really a switch you need to make in your head. Pro or fun, it's your decision and I chose to go pro!



Friis: Going from normal player to professional was not as spectacular as one might think, but came rather gradually. Shortly after I signed my first serious contract with a professional

organization, only a week after I was picked up, we flew to Changzhou - my first big event. Against all odds, we managed to win the tournament. The feeling was beyond any description and one of the main reasons I still compete. When I travelled home, everything was still normal - same life, and same friends, which made me appreciate this career path even more.



PiG: There was the gradual improvement, learning to compete, asking pros for advice and help, and joining various clans/practice groups. But the real step happened when I just found myself enjoying improving at StarCraft and actually feeling like I was becoming a smarter and better person. I'd be in class at uni and all I could think about was different strategies,

ways to handle different situations in games, how to orchestrate certain attacks. And yet it didn't feel like a negative addictive thing - it felt like this was just something I really wanted to do. I knew there were others out there making a living off the game, so I decided to dive in and start out by proving I could support myself as a coach. I was already doing some coaching as I'd started doing some for free for my clan, I found I enjoyed it and had a few requests so after doing it a little on the side, I decided, why not make this my job and keep improving at the game whenever I'm not coaching? I created my own coaching business and worked incredibly hard for a long time streaming, advertising myself through giving out free advice all over various forums and different outlets. I also gave lots of free coaching and different promotions to get exposure and refine my abilities at it - I always told myself if I'm going to charge money to coach a video game I better do a damned good job of it.

As I spent so much time building my coaching business, and still was practicing on the side, I literally gave up all social life whilst doing this. I had very little savings and was living out of home (albeit with very cheap rent) but I had to live off a very small income, and even if I wanted to, I literally had no time to spend socialising due to all my free hours being spent on practice. Pretty quickly I had a small, yet stable, income to support myself and was learning to improve on the side. This was the middle of 2011.



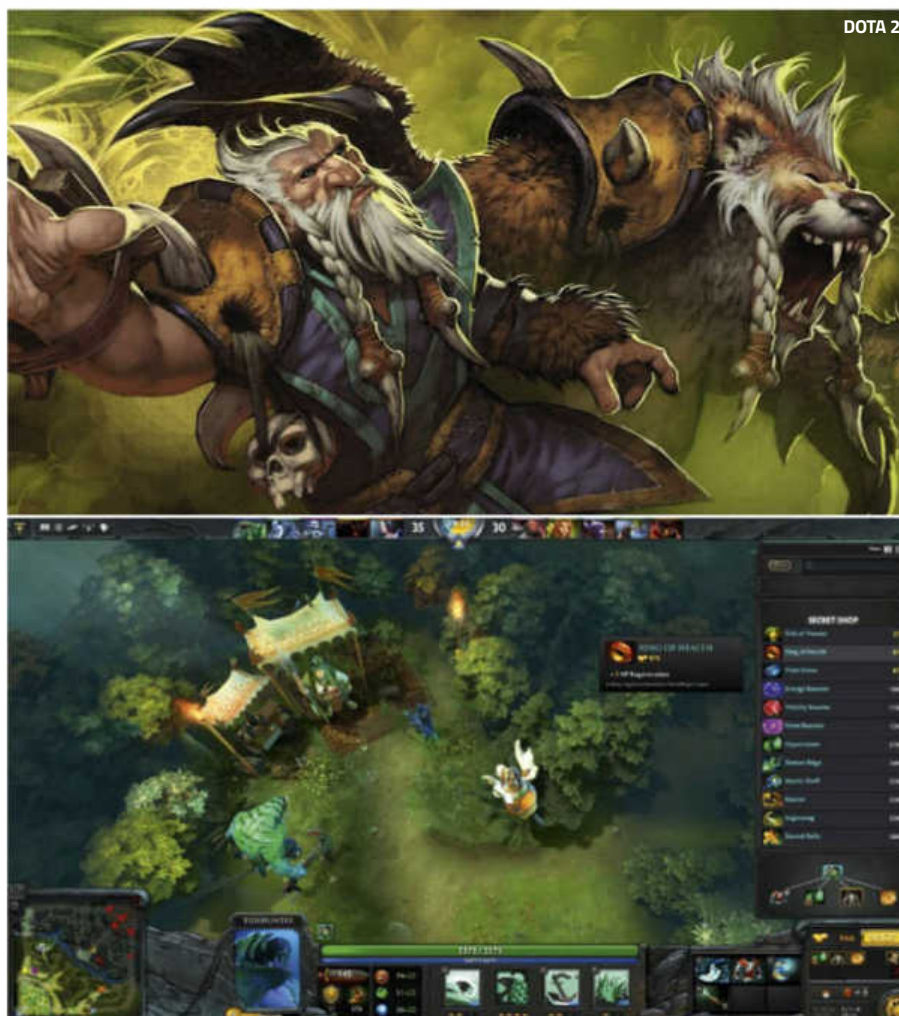
Sam "SamH" Hidalgo - TNC

(DOTA 2) - I can say that I'm a really passionate person when it comes to E-sports. And I worked very hard in order to become what I am now. You need to work harder than anybody else. Other people don't see that being pro is not just being good but working and training harder than anybody else.



Sybol: In terms of solo queue I would say focusing on each and every game to make sure you give yourself and your team the absolute best chance of winning. Basically looking at each game and knowing where I went wrong or what opportunities I missed and take that information into the next game.

For competitive, I'll be honest, I struggled. The transition wasn't easy and there's still SO much for me to learn. It took time to begin with and getting confidence against some of the best junglers in the region wasn't easy. It just comes down to your own play and how much you trust in your ability as a player. You practice, you improve and then you find out if it's enough to win.



Q: HOW DID YOU FIND YOUR TEAM AND SPONSOR/S?



Spookz: I found my team on ladder via Rusty (who is a Riot shoutcaster now) then gradually just moved on to different teams with Swiffer.



Faith: I tried some teams after I stopped playing Counter-Strike 1.6 and started again with CS: Source. I tried joining with a team of girls who I had never met before, but the team fell apart after a few weeks. One of the girls from the disbanded team wanted to build a new team with the girlfriend of one of my friends. The two asked me to join their new team, and we had fun playing together. That is how the new team was formed.

We wanted to search for a new sponsor after some disappointment with our old sponsor. We managed to get a slot right around that time for the Intel Challenge Katowice and received offers from many sponsors. We picked CMStorm

because we felt that we could trust them.



RedBull: At the beginning of the World of Tanks league, I saw a recruitment article and I decided to join a team. After that, I ended up joining another team by communicating with the other team captain through a community site. For sponsors, I actually contacted them when I was sourcing and gathering eSports information online.



Sybol: The same as most I'd say. Play a lot of solo queue, climb the ladder and get spotted. Despite what some pro's say, solo queue performance is very relevant to being noticed by players and teams.



Caren Tiger: We have no sponsors and created the team ourselves. We wanted as much freedom as

possible—we still call ourselves an amateur team. We think that is the best fit for us, because if are created by a vendor or a sponsor, or you are sponsored by a company, you can be limited by rules. You may have to wear their products when playing, which might be uncomfortable; you might not be able to use your best gear; you might have to do something to help promote their product, etc. So as an amateur team, we are free of these limitations and can do whatever we want. We really think that is the true way to enjoy the game and not be involved with commercial benefits.



KillyVe: I had no team at that moment and I was kind of searching for one but I didn't look for female teams. I was more searching for a team in Benelux with guys until I met Queen (Stephanie Eydens). She asked me if I wanted to be their 6th player because they already had a full line-up at the time. After a few days one of the girls left the team and I got the lucky invitation as their fifth player. After I accepted, the girls were really nice to me and we were all very motivated.

When our team qualified for the Intel Challenge Katowice we had no sponsor. There were a few organizations approached us during the tournament. CMStorm came with the strongest offer and I haven't regretted the decision since.



Carbon: The team I'm on currently still has some of its original members, but Legacy I built from the ground up. I decided I wanted to create my own brand in 2014 and see what I would be able to do with it. Since that time I've learned a lot about people, League of Legends and running a small business. Sponsors I found through networking mostly. It's important to try and maintain as many relationships in the industry as you can because you never know what might happen in the future!



Biggy: Avant Garde actually made a Reddit post saying they were interested in sponsoring a team within the scene. We had always considered them the benchmark organisation in Australia and we were doing very well at the time so we applied and they accepted.



Yada: I just played a lot of solo queue. Probably more than most. A lot of people even now remember me for being that one solo queue player who they would have to watch out for back then. Some of the players that I would often end up against back then make up all of my current teammates now, so I definitely attribute it to solo queue performance.



Q: HOW DID YOU GO ABOUT INCREASING YOUR SKILLS TO TAKE YOU UP TO THAT NEXT LEVEL?



KillyVe: I played the game a lot. I watched matches from better players. I tried out new stuff. I played online tournaments. I played on small/big LANs. I try to play as many LANs as I can because it is one of my weaknesses I need to work on my nervousness when people watching me during LANs. I need to get used to it and am working on getting my nerves under control, but it is taking me a bit longer than the others.



Glaive: I guess I was just playing a lot. When I found out my aim was able to compete with the best I started watching in-eye demos of especially Carn from CS 1.6 and FeTiSh from CS: S. When I watched the demos I wrote down all the patterns I could find for leading their teams to victory. I did not see it as work; I just wanted to become a complete player and be one of the smartest in the game.



Carbon: I think the biggest thing for me was beginning to really think critically about the game. Up until the point when I decided I wanted to be the best I was really just auto-piloting every game, doing the same things I knew would work and just doing my best, not to play well per se, but to win the game. Watching footage of myself as well as of other great players was another big step I took. It seems a lot like homework (because it is), but research will put you at a massive advantage compared to those who do not.



Destiny: I continued to notice my mistakes and fix them, watching VODS of myself, watching the international scene, working with coaching staff and using external websites such as probuilds.net



Yada: By playing alone I had no choice but to focus purely on my own gameplay and ways I could perform better if I had any interest in winning. After joining a team this meant I was comfortable in my mechanical skill, and progressing beyond this meant working largely on team chemistry.



SamH: The first thing really needed is passion. If you're not passionate enough you won't train hard enough.

Second thing is to train harder to improve my skills. When I say train harder it's not just playing many games but more like understanding the meta. What hero this hero is strong against and weak against, when to clash and when to farm. Etc.

Up until the point when I decided I wanted to be the best I was really just auto-piloting every game



Friis: I keep playing, simple as that. I spent multiple hours playing death match and watch as many demos of myself as possible. I study my own matches to get a better sense of the mistakes I make in order to improve. At the same time, I closely follow other players to get new ideas on how to position and always be on top of ongoing developments.



PiG: Nonstop hard practice. Always watching replays to improve, always looking to improve the slightest things to gain small edges. Learning from the best. Studying the game and writing copious amounts of notes to cement my knowledge, and help me explore issues. Debating and discussing on forums, and with team-mates, about different strategies and being forced to understand the game deeply through critical discourse. Never being satisfied and always looking for another edge I could take.

Starcraft 2



Q: WHAT IS YOUR TRAINING REGIMEN LIKE?



Derek "Raydere" Trang – The Chiefs (LoL):

My training regimen is quite sporadic at times but during non-exam periods it's quite stable. My day would generally consist of waking up at 10am, hitting the gym, eating lunch then begin individual practicing (Solo Queue) at around noon. From there I would practice till 6pm, having a 1 hour dinner break. Afterwards, I would have team practice from 7pm to midnight. Afterwards I would do some more individual practice until 3am before I sleep.



Faith: My team and I train five days a week. We rest on Fridays and Saturdays.

Sometimes we do online boot camps on the weekend and set aside days for streaming. We are trying to improve our gameplay with new tactics and also analyse our practice sessions, discussing what went wrong and what we can improve in the future.



PiG: It's varied throughout the years but when I'm fully focused on training it usually revolves around two 4 hour blocks of practice with lunch in between.

An hour of exercise at the end of the day followed by cooking/relaxing/spending time with my partner. Quite often the evening is spent watching the videos or live games of the best players, studying my own replays or running drills for new techniques – though this isn't set in stone.



Caren Tiger: Up until now, we're focused on World of Tanks. However,

we've found that if we have 2 matches in a day, we can lose our concentration. I think we need to start some kind of physical training mixed with Zen, mediation, etc.



Carbon: Currently it is very relaxed as it's off season for us, but during a normal season we as a team will usually put in around 2-3 hours a night, 4-5

days a week, of training as a group. Individually I would put in as much time as possible without encroaching too much on my other responsibilities. This equates to about 3-5 hours a day. This sort of regime is typical amongst OCE players as most are still having to work or are choosing to study while being a pro.



However I don't think it will be long before we see more experienced coaches.



Sybol: Solo queue. And lots of it. I think it's more important in OCE more so than the bigger regions

because teams from those regions scrim more seriously and more often. There is less teams because we're a small region, less time because almost all players have commitments outside of League and the coaching staff is still quite new and exclusive to only a select few teams. So it just puts more emphasis on solo queue in general.



Yada: We are scrim partners with Avant Garde, and we scrim them 5 nights a week, Sunday through Thursday.

Times vary, but typically we will begin scrimming 30 minutes after I get home from work, sometime between 7-9pm, and we will scrim to approximately 12:30am. Following this is post-scrim analysis, and any other free time is often spent queueing with the team.



Glaive: When we practice with the team, we do it 5 times a week for 4-6 hours. Besides practicing with the team, I play around 2-3 extra hours every day in my pursuit of becoming one of the best in the world.



KillyVe: We train five days a week and 1.5 hours on Mondays and Wednesdays. On those days, we use the rest of the time to talk about tactics, smokes and maps and what went wrong on

that map or what can be done better. On Tuesday, Thursday and Sunday we train for three and a half hours. Most of the time we search for matches to play against other enemies and try the stuff we talked about to see whether our team play improves. If not, we talk again and change some stuff and see if that works. We do this until we feel comfortable with our gameplay for that map.



Friis: As I said, I try to play as much as possible individually and within the team. Team practice takes place every day from Sunday to Friday, usually between 5 PM and 12 PM, if we don't have to play official league matches or tournaments in between. It's definitely hard to maintain a healthy social life or have a family even, but well worth it if you really want it and are fully committed.



Nathan Mott – Owner and Founder of Dire Wolves (LoL & SMITE):

Our League of Legends and Smite team have very similar training regimens. During the season they are usually practising 5-6 days a week, 4-6 hours a night.



Rowe: My training regimen includes 6-7 hours of scrims each night from Sunday to Thursday, followed by 2-3 hours of game review. Any further study or research is done in my own time, at any point I feel.



Team Manager – TNC (DOTA 2): The team's training schedule a bit strict. We make sure that necessary preparations are being done especially when there's a tournament. The team usually trains around 7-9 hours per day on a regular basis. But of course, adjustments are being made when there are tournaments or scrimmages against other professional teams.



Q: WHAT TIPS WOULD YOU GIVE GAMERS LOOKING TO TAKE THAT STEP UP TO PRO GAMING?



Raydere: Have a good honest assessment of yourself right now in terms of what you are looking to achieve as well as your talent level and lifestyle. Pro gaming is quite gruelling at times and most often the success that you are looking to achieve is only seen at the very top. People often ignore the climb and grind that it takes to become the best and as a result often end up unhappy with themselves, tilting due to unreasonable expectations. Staying headstrong is the most important aspect to pro-gaming and is a reason why you see so many young players with great potential fail horribly due to immaturity.



RedBull: I think the difference between amateur and pro gamer is playing a game for "fun" or "to be the best". Pro gamers spend their time and effort on putting on a good show for the fans and constantly practicing to get the best results. This means that we have to consider what we want to be. Do we want to play for "fun" or "to be the best?" The mindset is important.



Yada: Simply improve yourself. Set yourself specific goals, no matter how big or small. There was a time when I first queued ranked, and after calling my role I was told nobody had ever heard of me, so I had to play support instead. I resolved not to queue again until I was certain nobody could say that again. Set yourself personal goals and don't stop working towards them until you're satisfied with the results.



Sybol: Aim to improve yourself, not your elo. If you worry too much about what rank you are or the players you're playing with, you're going to have a bad time. It's about improving your play. Identifying flaws in your play. Identifying flaws in the enemies play. Working towards fixing the things that separate you from the pro's you watch. But at the same time, don't forget to enjoy the game.



Porky: Don't. It's extremely hard to be considered a pro, and in a small region like OCE the negatives outweigh the positives, but it is getting a little better!



Friis: Hang in there! Becoming a full-time time player is everything but easy. It takes a significant portion of commitment, dedication and stamina. Gamers have to put in hours over hours every day to become the best and internationally recognized for what they do - playing a video game. Work hard, try to improve every day, make sure you are mentally and physically fit and, last but not

It's extremely hard to be considered a pro, and in a small region like OCE the negatives outweigh the positives

least, get your name out there, either by participating in online leagues or smaller offline tournaments for organizations to notice you.



Biggy: You have to trust your own ability and work hard at improving. The biggest flaw most players have is they respect good or professional players so much to the point that it affects the way they play with/against them negatively.



PiG: Have a support network in place - it's the exact same as getting into a real sport, in that it will take years of hard work to get to the level where you can earn a steady living. However there's less of a beaten road, so you have to be self-reliant and self-driven. A lot of players get decent at a game and then just wish they had a team to take them to the next level. But that isn't how eSports works. Teams are there to provide sponsorship once you've already proven your skill and value. It's up to you as a player to get to that level.

Involve yourself in the community and learn from the best. Have a long-term plan. And never give up.



Faith: If you want to be a pro, you should work hard on yourself. It cannot be just a hobby because you have to invest time. You have to be dedicated about what you do and try to better yourself at every chance, to react in a better way in some situations and to take it more and more seriously. And of course, gaming should be your passion.



KillyVe: You need to love the game because you need to put a lot of time into it. Find teammates that have the same motivation as you. Check demos on how pro players play. Go to LANs or play online tournaments. Keep improving yourself and your team. Keep telling yourself "I want to be on the top" and eventually, you will. Never think you are good enough because no one is good enough: you can always be better.



Rowe: Be ready to invest a lot of time before achieving the big goals. You must find joy in the work, not just the glory.

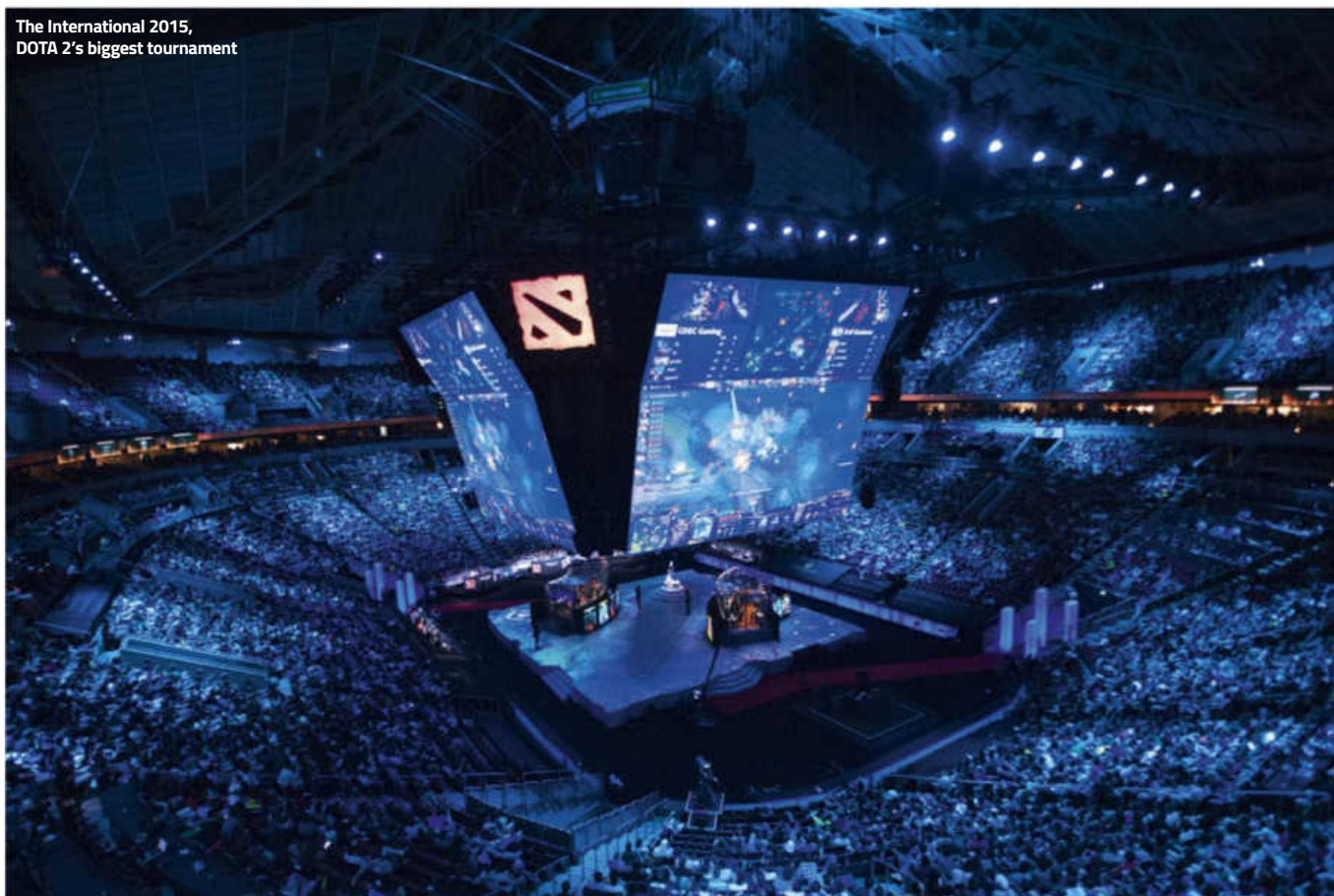


Carbon: For those who are interested in going to the next level, the best tip I can give you is be prepared to work hard. I am not a naturally gifted gamer, it took me uncounted hours to get to the level I am at. In my opinion with enough hard work most players could at least get to a competitive ranking.



A player deep in concentration at the 2012 StarCraft II World Championship Series: Oceania Finals

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Q: HOW LONG A PRO GAMER CAN EXPECT TO BE AT THE TOP OF THEIR GAME?



Raydere: Pro gamers will often go through phases where they have downswings in their level of gameplay. This is generally just all mental but if one stays headstrong and remain objectively self-critical, it is very easy to stay on top of your game.



Faith: I think a pro gamer can stay at the top for a long time, if they are always working hard and trying to reach their goal. You cannot just lean back and relax; there are always people who want to be at the top.



Friis: Most newcomer usually start getting recognized at the age of around 17 to 18, sometimes as early as 15 years, and have an average professional lifetime of about 10 years. Reflexes and physical fitness are not necessarily a limiting factor, but the intensive practice and travel schedule and a very

demanding lifestyle takes a toll on professional players over time.



RedBull: In my opinion, a pro gamer can maintain a top position for just 1-to-2 seasons. The higher up you go, the more time and effort is required. To constantly stay at the top of your game is extremely challenging.



Nathan Mott: Currently the lifespan of a pro gamer is very short. Most players begin at around 17-19 and will retire by 23-25. This is usually because they burn out from rigorous training regimens or are stressed from the constant pressure. Games like LoL and Smite change often so players are required to adapt constantly.



Sybol: I think it varies between players. It's all about motivation. Some players hit that 'wall' where they realise it's time to move on. Others, if the

passion is still there, could continue playing at their peak for much longer. I don't think age and reaction times affect a player enough to consider them not good enough. Experience is simply more valuable.



Yada: I don't think there's any set time, it's all about motivation. I've seen players stop improving entirely, or even become worse because of lack of motivation. I've also seen players continue to grow and even improve massively because of their passion for the game. It's all down to each individual and how long they can sustain their love for the competitive aspect of the game.

Currently the lifespan of a pro gamer is very short. Most players begin at around 17-19 and will retire by 23-25

Q: DO YOU MAKE ENOUGH MONEY THROUGH GAMING TO SUPPORT YOURSELF OR IS PRO-GAMING MORE OF A PAID HOBBY FOR YOU?



Raydere: Because Oceania is a relatively smaller region, pro-gaming is enough to support myself during university. Due to our recent success, it has become more than a paid hobby but ultimately will not be anywhere close to a fulltime job. As for now, I would define it as a part-time job that I thoroughly enjoy doing.



Glaive: I make enough money to support myself. I got my own apartment in Copenhagen, and do not need another job.



Nathan Mott: For all of my players, pro-gaming is a paid hobby for them. The Oceanic eSports scene is very far behind other regions, but we are rapidly developing. I expect that we'll be seeing player salaries by 2018 and hope all of my teams will be full time by 2020.



Biggy: Right now it is very much a paid hobby, but hopefully that may change in the months and years to come thanks to companies like Hi-Rez investing big in their eSports scene and its players.



Porky: It's just a hobby it's not a type of work that can make you money in Australia, in other regions like China, Korea, North America, EU it's definitely possible.



SamH: Yes I believe that it's self-sustainable for me plus I can do what I love and what I'm passionate for. Not all players are given this opportunity so I'm really thankful.



John Linuel "Teehee" Abanto – TNC (DOTA 2): It's much like 50-50 because the money they gave me I always share it to my family so that they know for sure that I will be always enjoying my life as a gamer and not just as a hobby.



Sybol: I would definitely consider it closer to a paid hobby than anything else. In Australia it's not realistic to purely sustain yourself off of pro-gaming. Down the road, as eSports continues to grow, I think we will see the continued support towards organisations and players that will allow pro-gaming to be something players can do full time.



PiG: It's my full-time job. However to make that viable as I'm not in the top 10 non-Korean players in the world, and I live in Australia (expensive to fly us to compete at the big events, and high costs of living), I do a variety of things within the professional gaming space. I'm not just a StarCraft Athlete but also a commentator, live-streamer and coach. These days I earn \$50/hour for coaching, and as of this year, I

commentate many of the biggest StarCraft events in the world, so I make a comfortable living, but it's been a long road getting here.



Caren Tiger: In Japan, we don't earn enough money. It's the same everywhere. Some of us go to school, some of us go to work. We treat it as a hobby, not really a profession.



Team Manager - SK Gaming (CS: GO): The answer to this question largely depends on the popularity of the game. In League of Legends, DOTA 2 and Counter-Strike: Global Offensive, the three leading eSports disciplines, pro-gaming is well-paid full-time job that enables players to save up money for retirement. Other games may not be as lucky, but still provide a number of income opportunities, e.g. through live-streaming or personal endorsements, for players to consider it a career path.



Carbon: In terms of money gaming is more of a paid hobby, I have had to work through my entire career. That being said I am doing everything in my power at Legacy to change that both for myself and for those that follow after me.



Yada: At the moment it's absolutely only a paid hobby. There has not yet been any sustainable income in Smite that anybody would be able to live off of, and so many players either work or study. However, after the huge first year that Smite has enjoyed in Oceania I think we can expect to see a lot more out of it in the years to come, and so living off of pro gaming alone could certainly be a reality in future. 🇨🇦





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